EXPERIMENTS IN THE WESTERN ATLANTIC NORTHEAST DISTANT WATERS TO EVALUATE SEA TURTLE MITIGATION MEASURES IN THE PELAGIC LONGLINE FISHERY

REPORT ON EXPERIMENTS CONDUCTED IN 2001 and 2002
March 5, 2003

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National Oceanic and Atmospheric Administration
NOAA Fisheries

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Western Atlantic Pelagic Longline Sea Turtle Mitigation Research Report
Executive Summary

Five potential mitigation techniques were evaluated during 687 research sets in 2001 and 2002. Data were collected to evaluate the effectiveness of the mitigation measures and to investigate variables that effect sea turtle interaction rates with pelagic longline gear. The results of this research indicate that a significant reduction in loggerhead catch may be achieved by reducing daylight soak time. 18/0 circle hooks and mackerel bait were found to significantly reduce both loggerhead and leatherback sea turtle interactions when compared with industry standard J hooks and squid bait. Also, circle hooks significantly reduced the rate of hook ingestion by the loggerheads, reducing the post-hooking mortality associated with the interactions. The combination of 18/0 circle hooks and mackerel bait was found to be the most efficient mitigation measure for both loggerhead and leatherback turtles. Mackerel bait was found to be more efficient for swordfish than squid bait and circle hooks were more efficient for tuna than J hooks. (Reports available online at http://www.mslabs.noaa.gov/mslabs/docs/pubs.html)

year	number of individuals	species	population	life_ stage	sex	origin	take activity category	125 KHz PIT tag	inconel flipper tags	other tag (satellite)	biopsy sample	location	details
2001	1	Caretta caretta	unknown	juvenile	unknown	wild	capture, handle, measure, release	No	Yes	No	Yes	Grand Banks, N. Atlantic	
2001	29	Caretta caretta	unknown	juvenile	unknown	wild	capture, handle, measure, release	Yes	Yes	No	No	Grand Banks, N. Atlantic	
2001	96	Caretta caretta	unknown	juvenile	unknown	wild	capture, handle, measure, release	Yes	Yes	No	Yes	Grand Banks, N. Atlantic	
2001	2	Caretta caretta	unknown	juvenile	unknown	wild	capture, handle, measure, release	Yes	Yes	Yes	No	Grand Banks, N. Atlantic	PAT tags
2001	14	Caretta caretta	unknown	juvenile	unknown	wild	capture, handle, measure, release	Yes	Yes	Yes	Yes	Grand Banks, N. Atlantic	PAT tags
2001	77	Dermochelys coriacea	unknown	unknown	unknown	wild	capture, handle, release	No	No	No	No	Grand Banks, N. Atlantic	
2002	2	Caretta caretta	unknown	juvenile	unknown	wild	capture, handle, measure, release	No	No	No	No	Grand Banks, N. Atlantic	
2002	2	Caretta caretta	unknown	juvenile	unknown	wild	capture, handle, measure, release	Yes	Yes	No	No	Grand Banks, N. Atlantic	
2002	85	Caretta caretta	unknown	juvenile	unknown	wild	capture, handle, measure, release	Yes	Yes	No	Yes	Grand Banks, N. Atlantic	
2002	11	Caretta caretta	unknown	juvenile	unknown	wild	capture, handle, measure, release	Yes	Yes	Yes	Yes	Grand Banks, N. Atlantic	6 PAT tags & 5 conventional satellite tags
2002	39	Dermochelys coriacea	unknown	unknown	unknown	wild	capture, handle, release	No	No	No	No	Grand Banks, N. Atlantic	
2002	118	Dermochelys coriacea	unknown	unknown	unknown	wild	capture, handle, release	No	No	No	Yes	Grand Banks, N. Atlantic	
2002	1	Dermochelys coriacea	unknown	unknown	unknown	wild	capture, handle, release	No	Yes	No	Yes	Grand Banks, N. Atlantic	

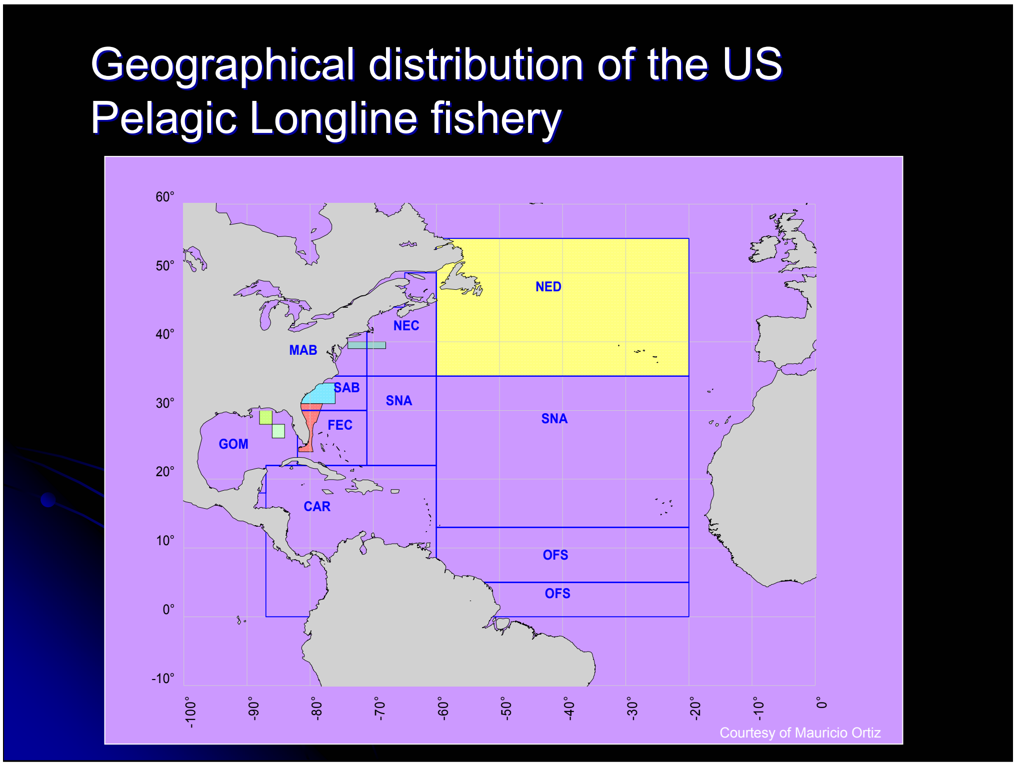
MARINE MAMMALS AND SEABIRDS TAKEN IN NED EXPERIMENTS 2001-2002

NUMBER OF INDIVIDUALS	YEAR	GROUP	COMMON_NAME	STATUS	LENGTH (CM)	LOCATION
1	2001	MARINE MAMMAL	DOLPHIN RISSOS	alive	250	Grand Banks, North Atlantic
1	2001	MARINE MAMMAL	DOLPHIN RISSOS	alive	230	Grand Banks, North Atlantic
1	2001	MARINE MAMMAL	DOLPHIN RISSOS	alive	275	Grand Banks, North Atlantic
1	2001	MARINE MAMMAL	STRIPED DOLPHIN	alive	200	Grand Banks, North Atlantic
1	2001	MARINE MAMMAL	WHALE NORTHERN BOTTLENOSE	alive	540	Grand Banks, North Atlantic
1	2001	MARINE MAMMAL	DOLPHIN RISSOS	alive	230	Grand Banks, North Atlantic
1	2001	SEA BIRD	SEABIRD	dead	150	Grand Banks, North Atlantic
1	2002	MARINE MAMMAL	COMMON DOLPHIN	alive	210	Grand Banks, North Atlantic
1	2002	MARINE MAMMAL	DOLPHIN RISSOS	alive	240	Grand Banks, North Atlantic
1	2002	MARINE MAMMAL	DOLPHIN	alive	165	Grand Banks, North Atlantic
1	2002	MARINE MAMMAL	DOLPHIN RISSOS	alive	270	Grand Banks, North Atlantic
1	2002	MARINE MAMMAL	DOLPHIN	alive	150	Grand Banks, North Atlantic
1	2002	MARINE MAMMAL	DOLPHIN RISSOS	alive	200	Grand Banks, North Atlantic
1	2002	MARINE MAMMAL	DOLPHIN RISSOS	alive	150	Grand Banks, North Atlantic
1	2002	MARINE MAMMAL	MARINE MAMMAL	alive	600	Grand Banks, North Atlantic
1	2002	MARINE MAMMAL	PILOT WHALE	alive	180	Grand Banks, North Atlantic
1	2002	SEA BIRD	SEABIRD	alive		Grand Banks, North Atlantic
1	2002	SEA BIRD	SEABIRD	alive		Grand Banks, North Atlantic
1	2002	SEA BIRD	SEABIRD	alive		Grand Banks, North Atlantic
1	2002	SEA BIRD	SHEARWATER SPP	alive		Grand Banks, North Atlantic
1	2002	SEA BIRD	GANNET NORTHERN	alive		Grand Banks, North Atlantic
1	2002	SEA BIRD	SHEARWATER SPP	dead	65	Grand Banks, North Atlantic
1	2002	SEA BIRD	SHEARWATER GREATER	dead	60	Grand Banks, North Atlantic
1	2002	SEA BIRD	SHEARWATER GREATER	dead	60	Grand Banks, North Atlantic
1	2002	SEA BIRD	SHEARWATER GREATER	dead	60	Grand Banks, North Atlantic
1	2002	SEA BIRD	SHEARWATER GREATER	dead	70	Grand Banks, North Atlantic
1	2002	SEA BIRD	SEABIRD	dead		Grand Banks, North Atlantic
1	2002	SEA BIRD	SHEARWATER SPP	dead		Grand Banks, North Atlantic
1	2002	SEA BIRD	SEABIRD	dead	120	Grand Banks, North Atlantic

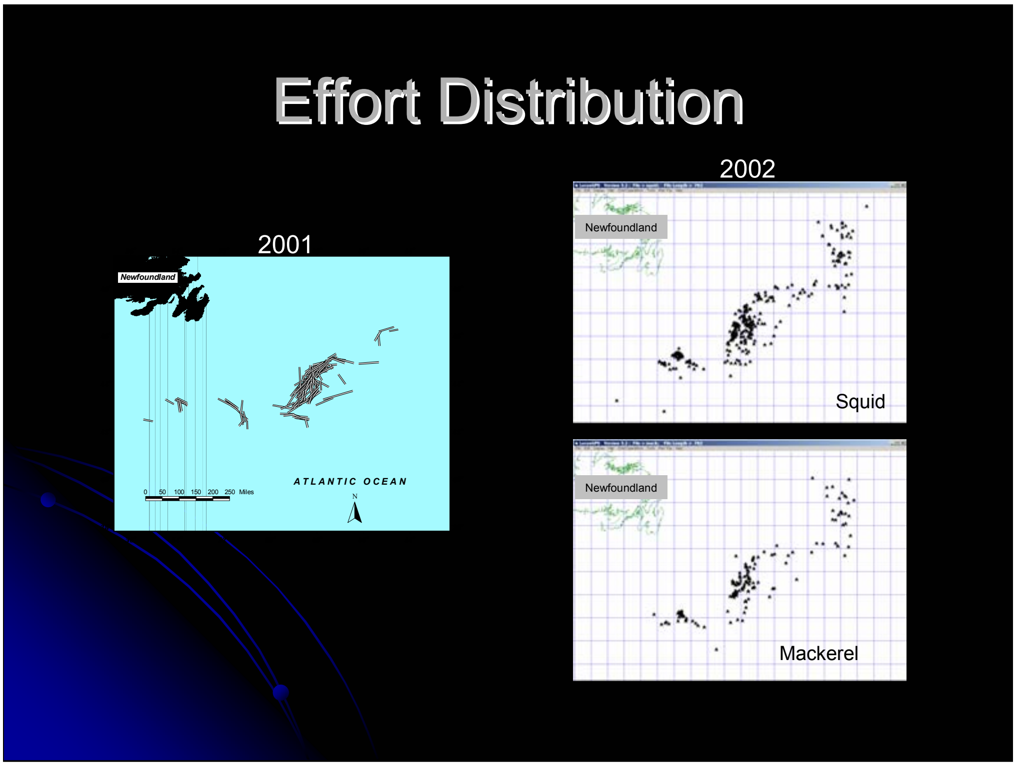
Western Atlantic Pelagic Longline Sea Turtle Mitigation Research

John Watson, Dan Foster, Sheryan Epperly, Arvind Shah

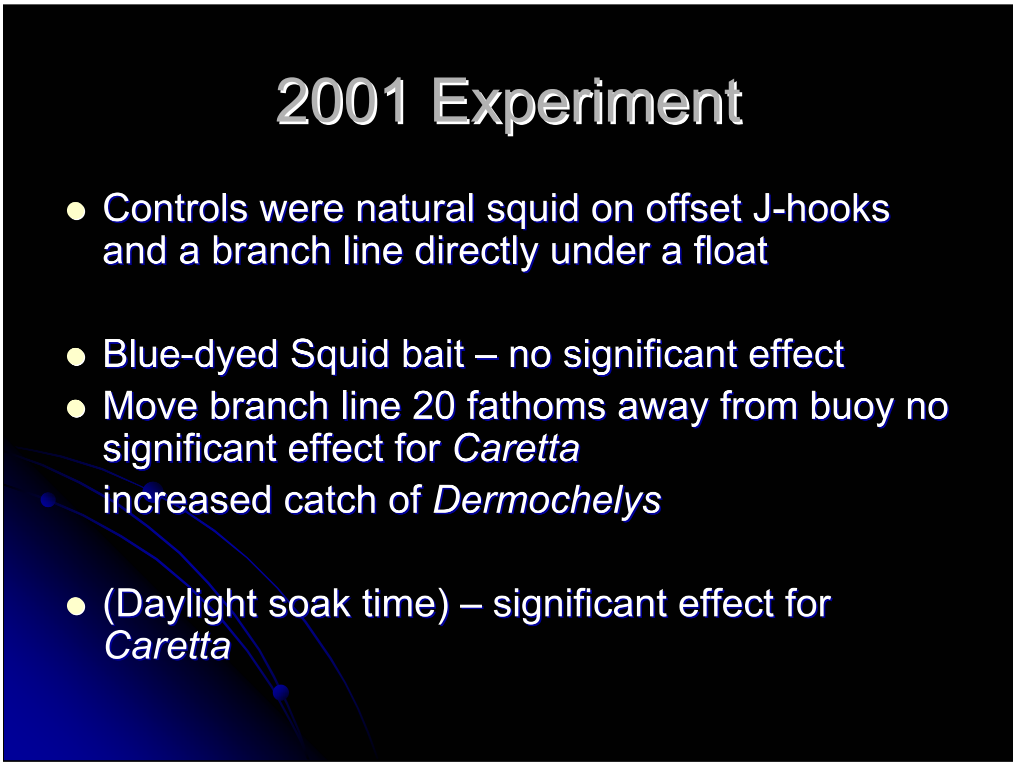
NOAA Fisheries in cooperation with the Blue Water Fishermen's Association is conducting research in the Western Atlantic Ocean to develop and evaluate fishing gear modifications and tactics to reduce the incidental capture of endangered and threatened sea turtle species by pelagic longline fishing gears. A three year project was initiated in 2001 and two years of research have been completed. The following presentation is a summary of the results of this research to date.



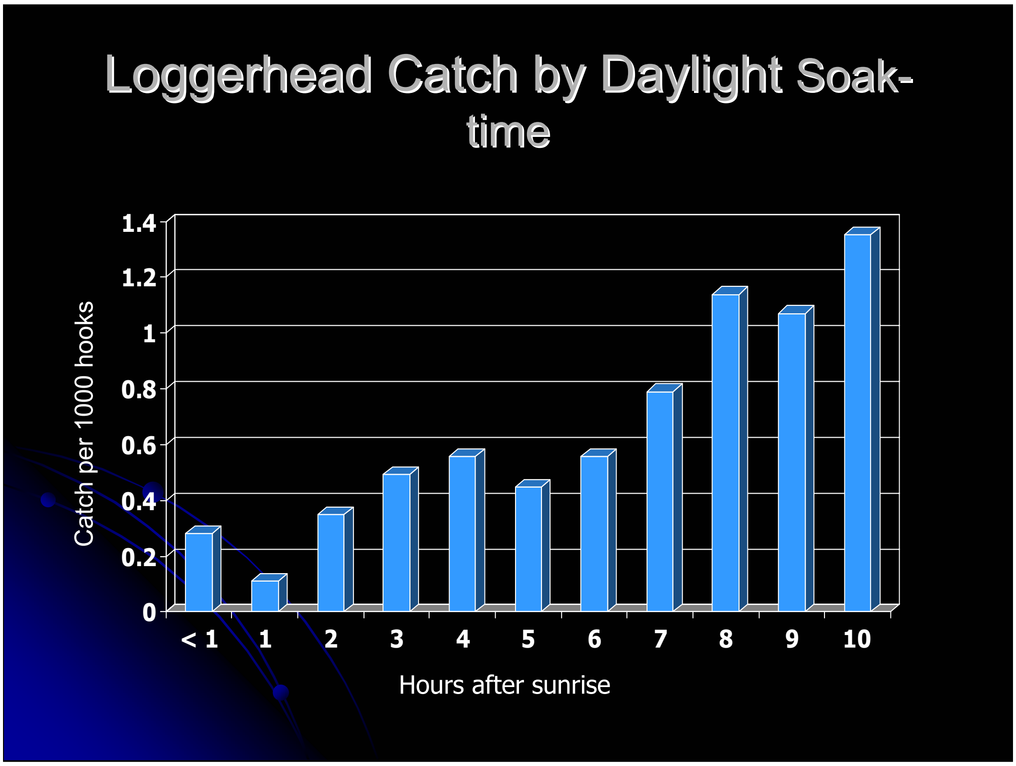
The area of operation was the Northeast Distant Waters (NED) statistical reporting zone in the Western Atlantic Ocean. The NED area is closed to pelagic longline fishing by U.S. flag vessels by regulation with the exception of the experimental fishery. In 2001 eight commercial pelagic longline vessels participating in the experimental fishery made 186 research sets, and in 2002 thirteen vessels made 501 research sets testing potential sea turtle mitigation techniques.



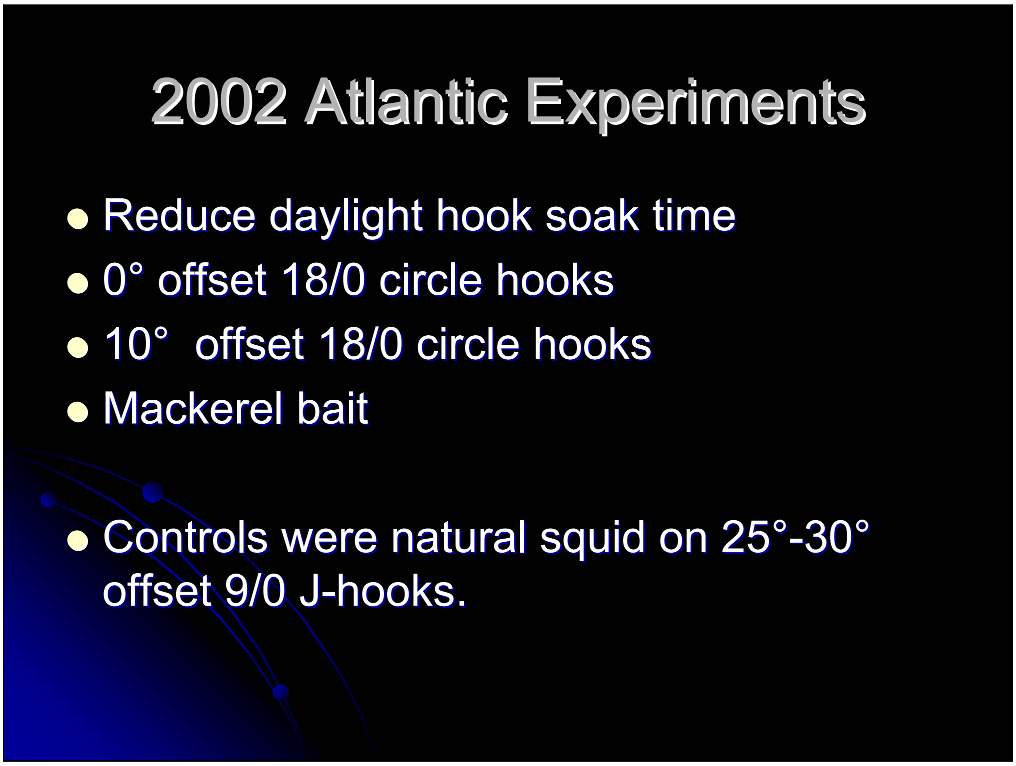
This figure shows the effort distribution by year and for different bait types for the 2002 experiments.



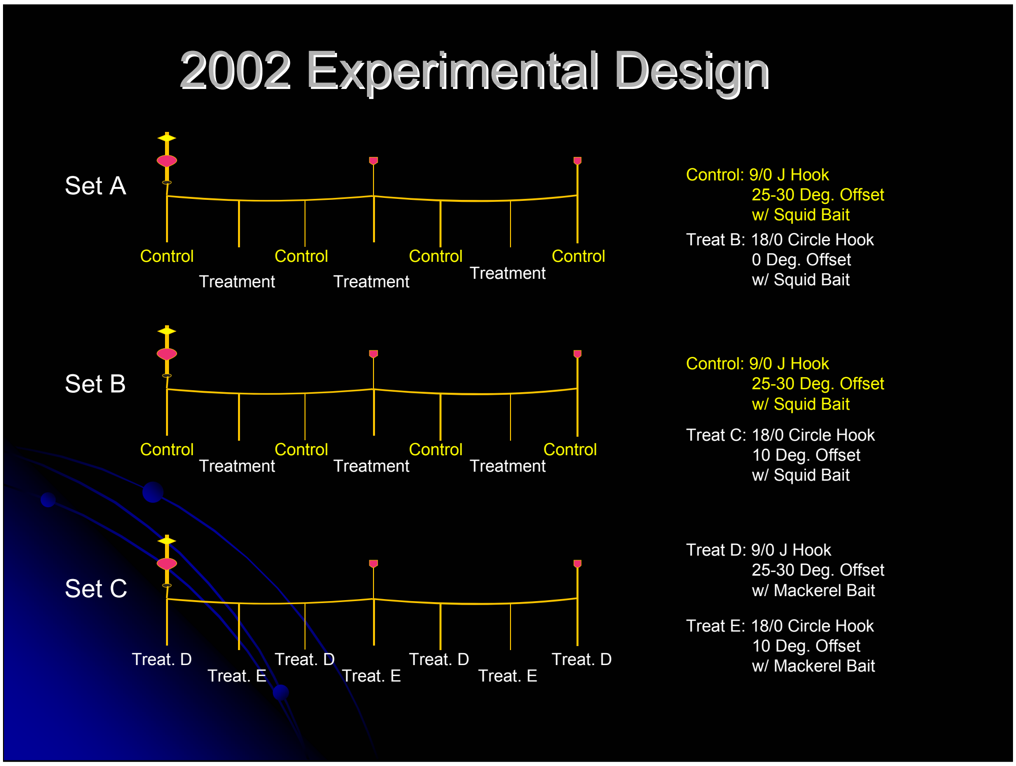
In 2001 the research experimental design was to test the effect of moving hooks that are normally deployed very near floats to 20 fathoms away from floats as historical data indicates a higher turtle take proportion on the hooks nearest floats. The design also tested the effect of using blue dyed squid rather than the standard squid as bait. Data on eighteen other variables were also collected to determine their effect on turtle capture rates. Analysis of the data collected in 2001 indicated that there was no significant effect of blue dyed squid on turtle capture rates and that there was an increase capture rate for leatherback turtles on the hooks placed 20 fathoms from floats. A general linear model indicated that daylight hook soak time (the amount of time the hooks are in the water during daylight hours) was the only variable which effected loggerhead turtle capture rates, but there was no effect of daylight soak time for leatherback turtle captures.



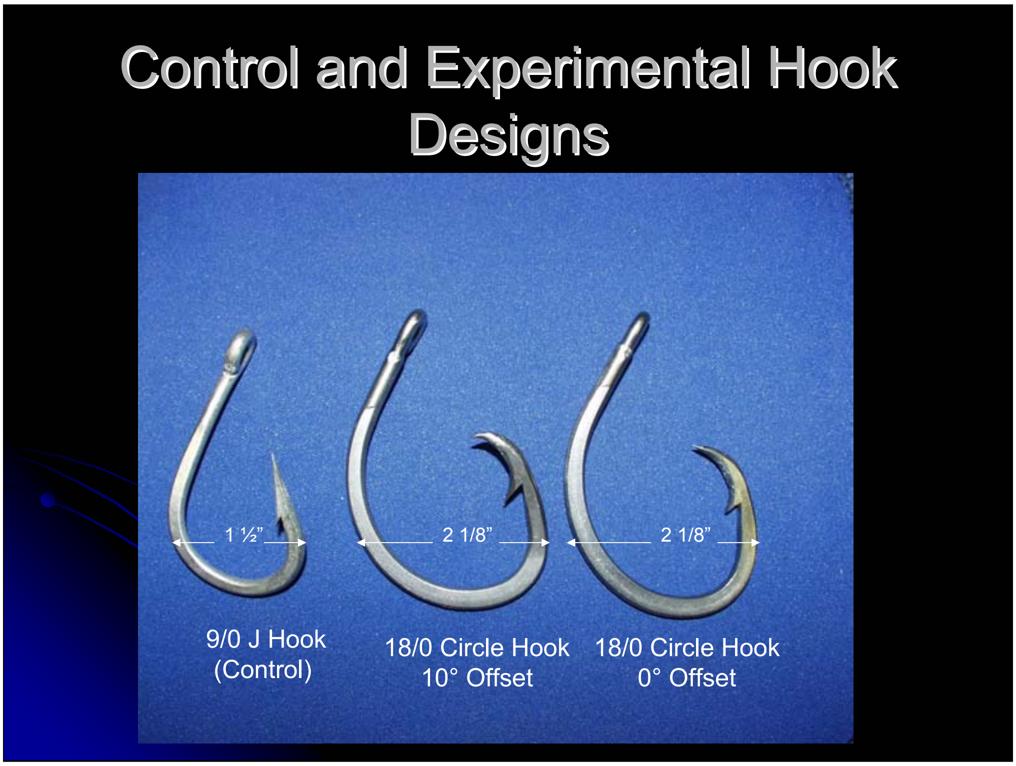
Loggerhead cpue increases significantly with increased daylight hook soak time indicating that loggerhead interaction with longline gear in the NED is a daytime interaction.



In 2002 the experimental design evaluated the effect of reducing daylight hook soak time, the use of 18/0 circle hooks both offset and non offset with squid bait, and the use of mackerel bait on both J hooks (control) and 18/0 circle hooks in reducing sea turtle interactions with pelagic longline gear.



Each vessel participating in the experiment alternated three sets (A,B,C). SET A alternated control J hooks with squid with 18/0 non offset circle hooks with squid bait in a non repeating pattern with 3 hooks between floats. SET B alternated control J hooks with squid bait and 18/0 offset circle hooks with squid bait. SET C alternated J hooks with mackerel bait with 18/0 offset circle hooks with mackerel bait. All other gear specifications was standardized within and between vessels. All vessels were given a target window to have all gear hauled in order to evaluate the effect of reduced daylight hook soak time.



The control hook used in the experiments was the standard 9/0 J type typically used in this fishery with an offset of 25-30 degrees. The experimental hook was an 18/0 circle hook specially designed by the fishers and a fishing gear manufacturer for this experiment. The 18/0 circle hooks were tested with no offset and a 10 degree offset. The 18/0 size circle hook was chosen because research in the Azores by the University of Florida has shown significantly less deep ingestion of hooks by turtles with 16/0 circle hooks and feeding behavior studies by NOAA Fisheries indicates that loggerhead turtles of the size encountered by the pelagic longline fishery have difficulty swallowing objects larger than 2 inches in diameter.

Circle Hook Design

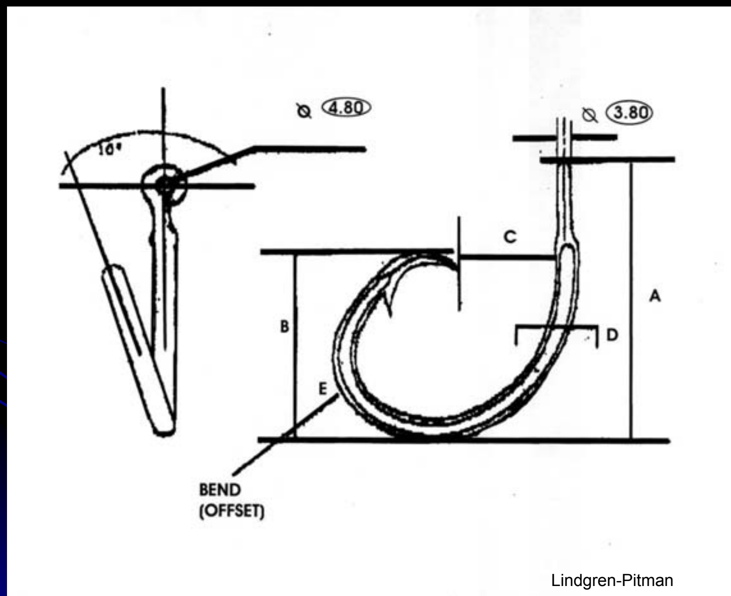
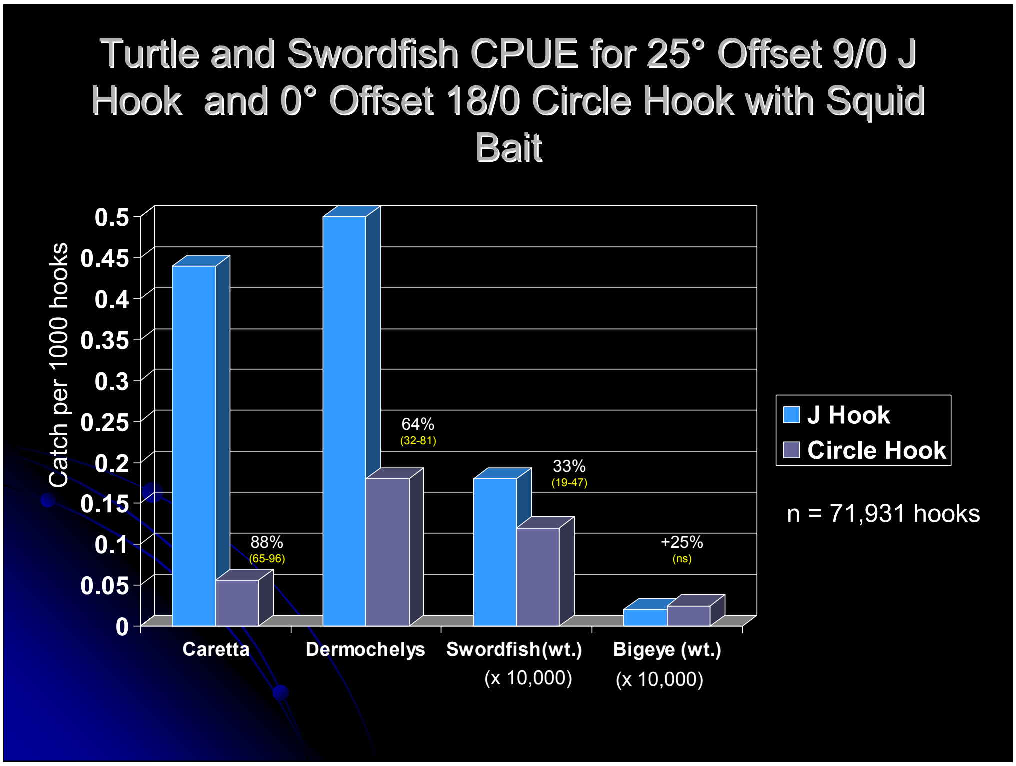
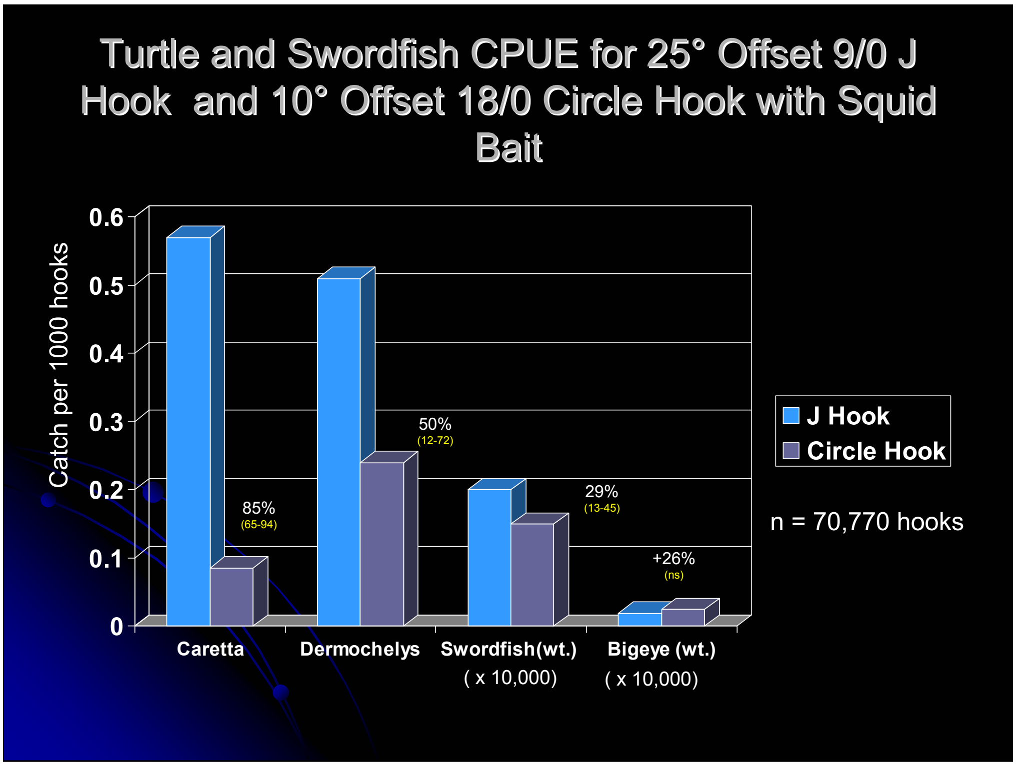


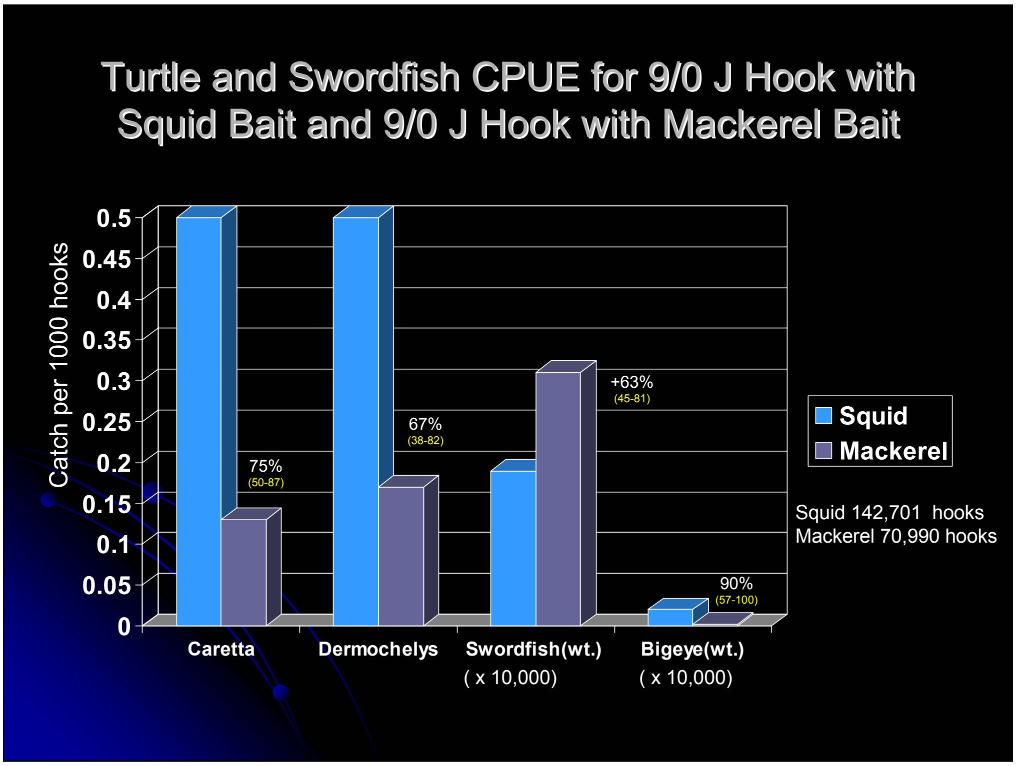
Diagram of the 18/0 circle hook evaluated in these experiments.



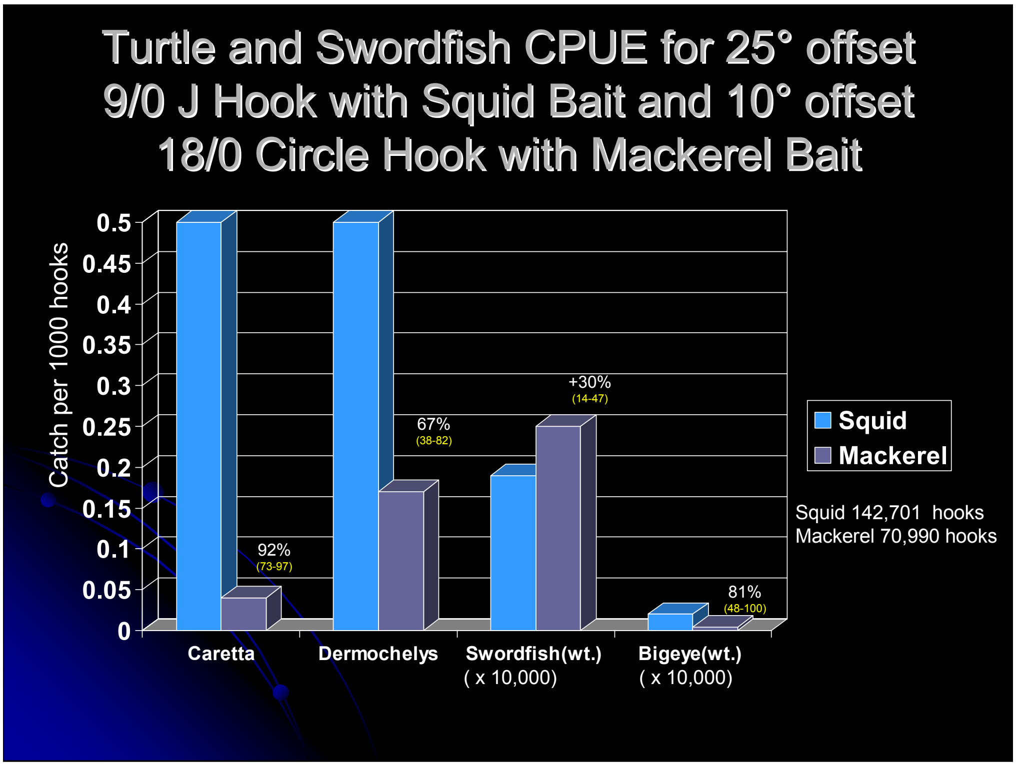
Both loggerhead and leatherback turtle catch rates were significantly reduced for the 18/0 non offset circle hook with squid bait compared to the J hook with squid bait. The mean reduction rate for loggerhead turtles was 88% with a 95% confidence interval of 65% to 96%. The mean reduction rate for leatherback turtles was 64% with a 95% confidence interval of 32% to 81%. There was a mean loss of swordfish by weight of 33% with a 95% confidence interval of 19% to 47%. There was a nominal increase in bigeye tuna catch by weight of 25% which was not found to be statistically significant.



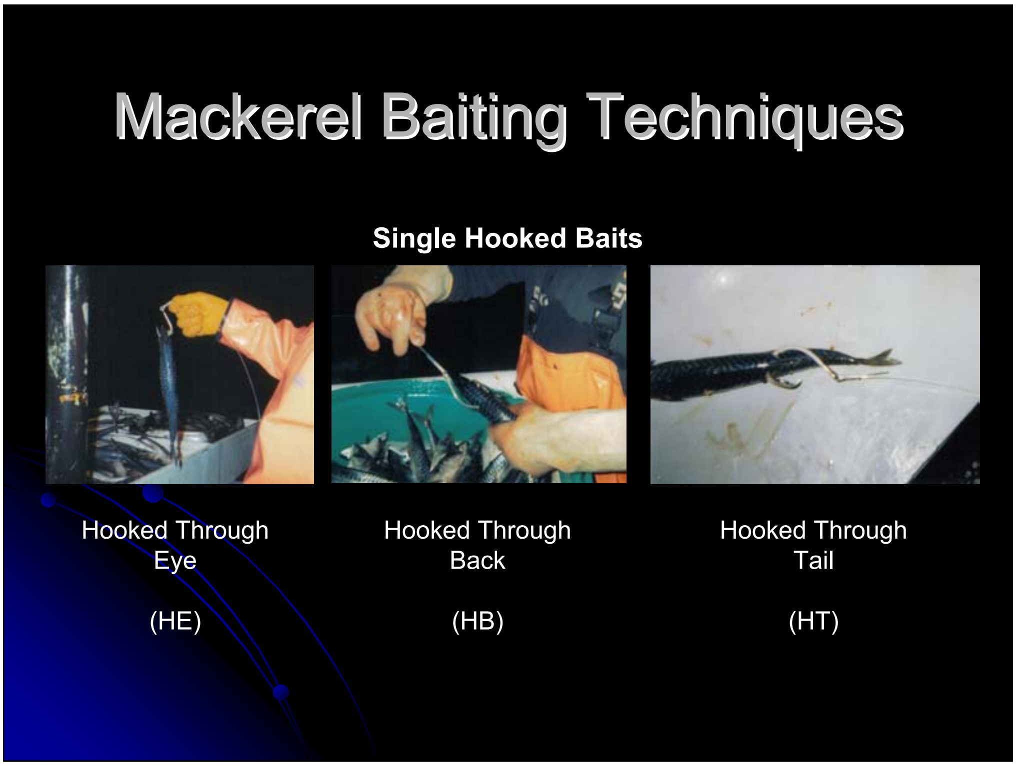
Loggerhead and leatherback turtle catch rates were also significantly reduced with the 18/0 offset circle hook with squid bait compared to the J hook with squid bait. The mean reduction rate for loggerhead turtles was 85% with a 95% confidence interval of 65% to 94%. The mean reduction rate for leatherback turtles was 50% with a 95% confidence interval of 12% to 72%. There was a 29% mean reduction rate for swordfish by weight with a 95% confidence interval of 13% to 45%. There was a nominal increase in bigeye tuna catch which was not determined to be statistically significant.



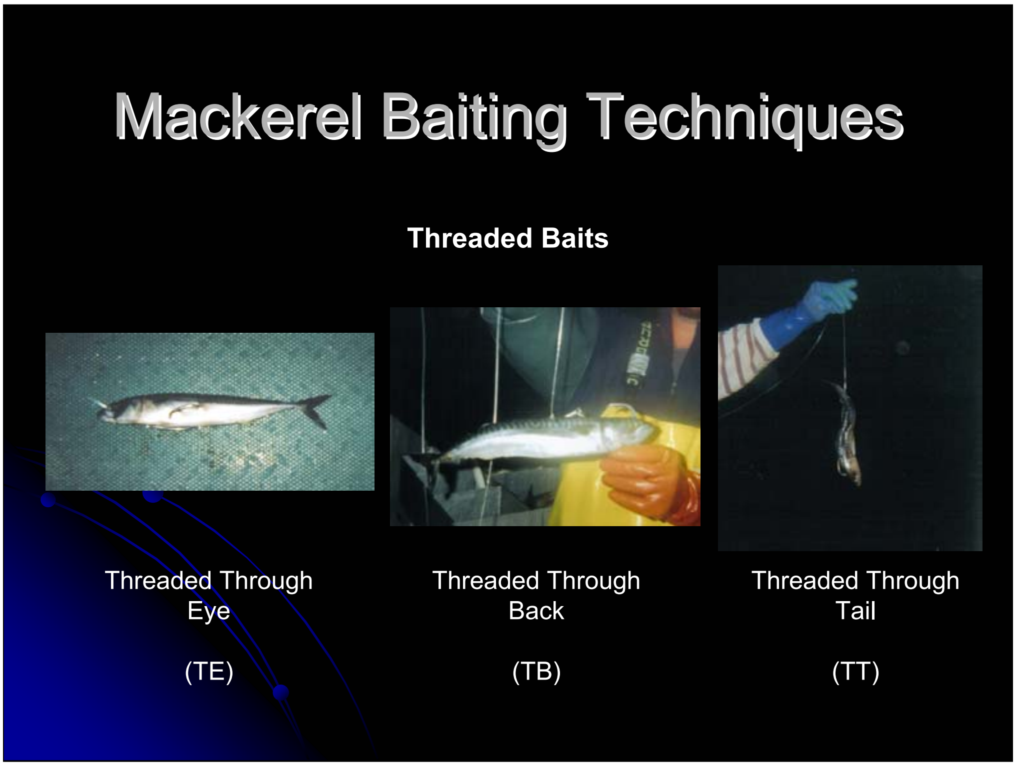
Loggerhead and leatherback turtle catch rates were also significantly reduced by using mackerel as bait rather than squid on J hooks. There was a mean loggerhead turtle reduction rate of 75% with a 96% confidence interval of 50% to 87% using mackerel bait. For leatherback turtles the mean reduction rate was 67% with a 95% confidence interval of 38% to 82%. There was a 63% mean increase in swordfish catch by weight with a 95% confidence interval of 45% to 81% when using mackerel. There was a 90% reduction in bigeye tuna catch by weight with a 95% confidence interval of 57% to 100%.



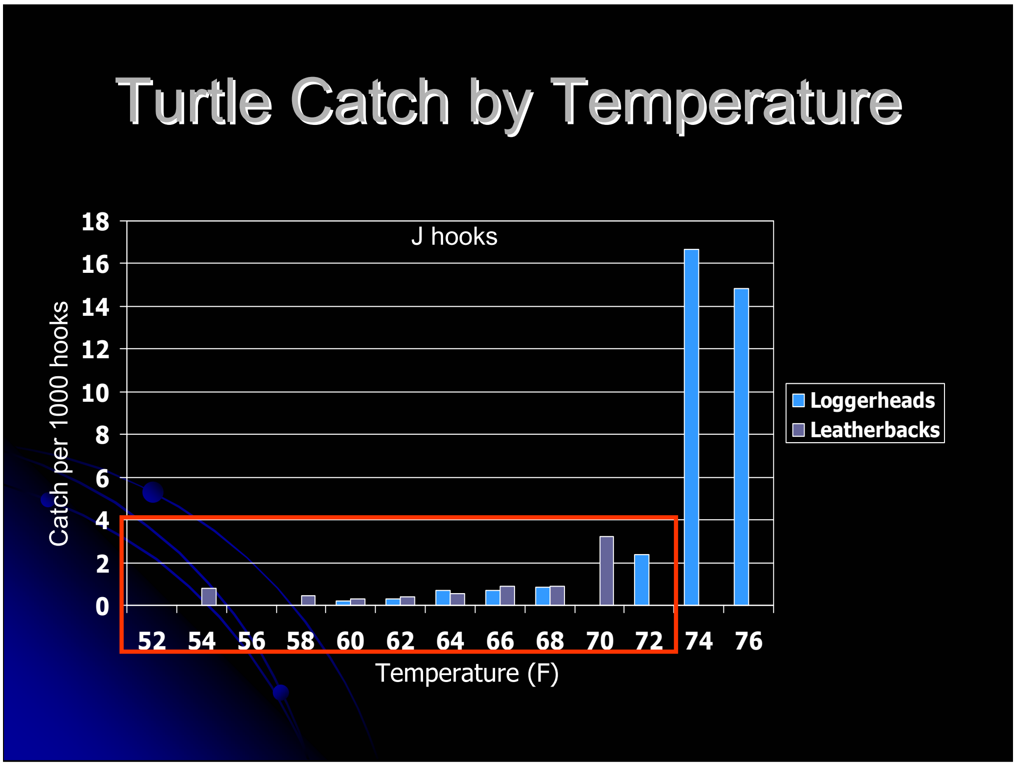
The best reduction rate for loggerhead turtles was achieved using a combination of mackerel bait with an 18/0 offset circle hook. The mean reduction rate for loggerhead turtles was 92% with a 95% confidence interval of 73% to 97%. The mean reduction rate for leatherback turtles was 67% with a 95% confidence interval of 38% to 82%. There was an increase in swordfish catch by weight of 30% with a 95% confidence interval of 14% to 47%. There was a mean loss of 81% for bigeye tuna by weight with a 95% confidence interval of 48% to 100%.



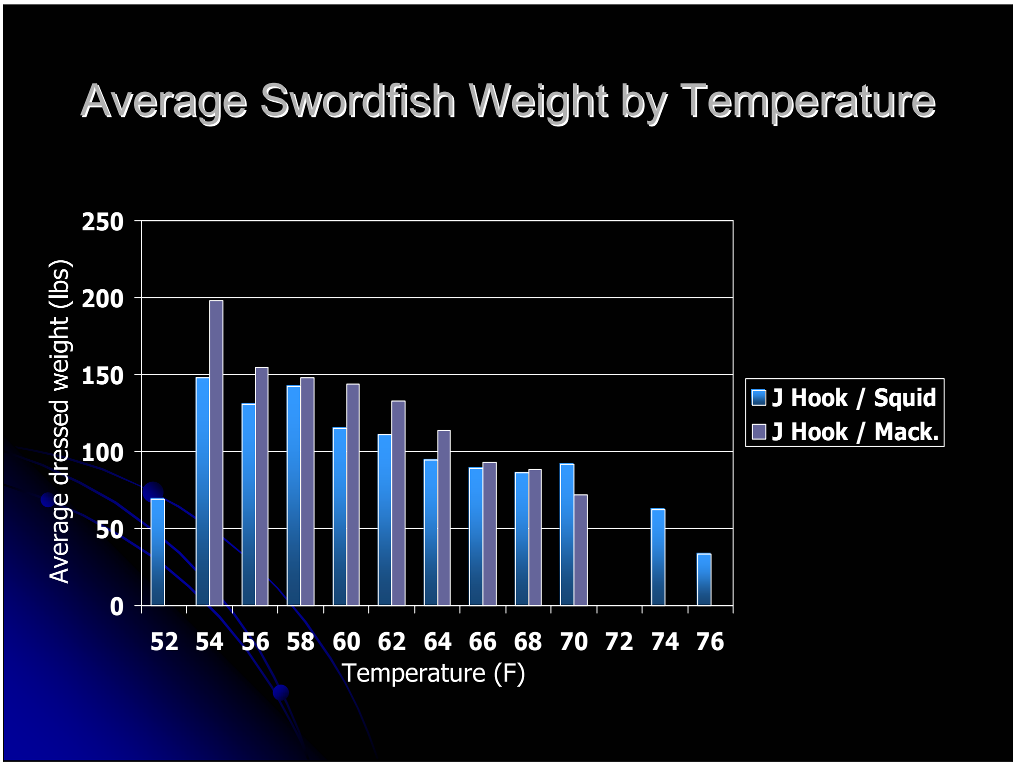
Observers documented the mackerel hooking techniques employed by the vessels during this study. Approximately 1/3 of the vessels used a single hooking technique which involved passing the hook point a single time through the bait through the eye, back or tail.



Two thirds of the vessels employed a threading technique which involved passing the entire hook through the body multiple times starting through the eyes, back, or tail. The threading technique was used to better secure the bait to the hook. The loggerhead turtle catch was 74% higher with this technique as compared the single hooked mackerel. This result may be due to the fact that the single hooked baits are more easily torn away from the hooks during the feeding process. However, the single hooked baits had a 107% higher leatherback catch rate than the threaded bait. This is likely due to the shielding effect offered by the threading of the baits. The single hooked baits also had the highest catch rates of swordfish.

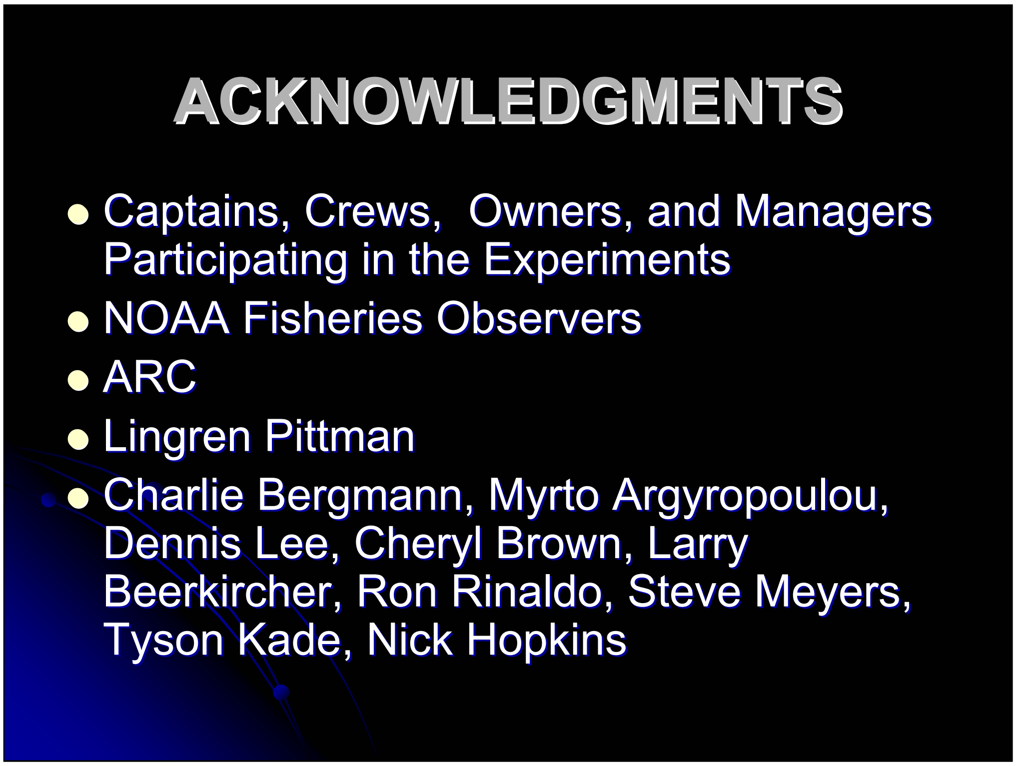


Both loggerhead and leatherback turtle catch rates varied with the surface water temperature. There was a dramatic increase in loggerhead catch rates for water temperature over 72 degrees (F). There was also an increase in leatherback turtle catch rates for water temperatures over 68 degrees (F). This data indicates that turtle interaction rates can be reduced by fishing in cooler water temperatures.



The effect of surface water temperatures was the reverse for swordfish catch by weight. The average dressed weight increased with cooler water temperatures (below 68 degrees F).

This data indicates that a fishing water temperatures below 68 degrees (F) can significantly reduce loggerhead turtle interactions while increasing target catch rates.

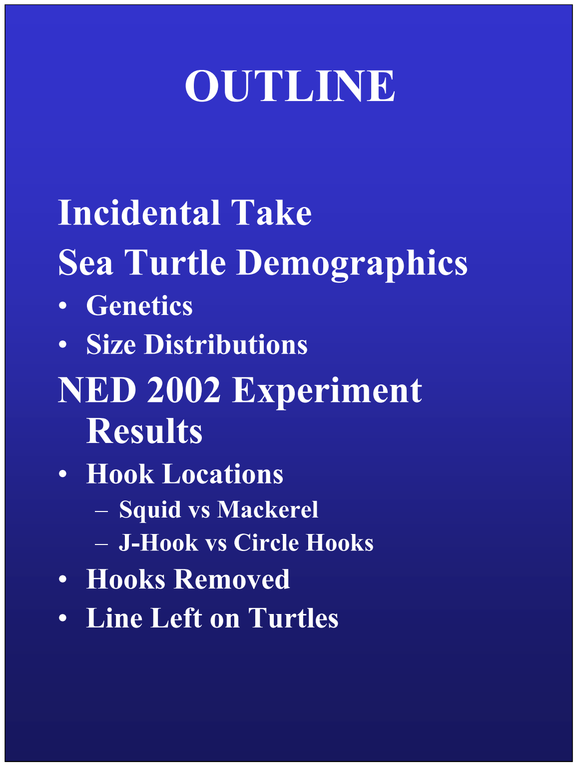


This success of this research is due to the hard work and dedication of many individuals within the fishing industry and NOAA Fisheries. The principal investigators would like to give special recognition to the vessel captains, crews, owners, and managers from Bluewater Fishermen’s Association who’s expertise and efforts were invaluable. We would also like to especially thank the NOAA Fisheries observers who “go the extra mile” in collecting enormous amounts of quality data at sea and are the pulse of the research. We would like to thank Aquatic Research Conservation (ARC) for their tireless efforts in developing and modifying turtle release gear used in the experiments and to Lingren Pittman for developing the hook designs used in the experiments. A very special thanks to Charlie Bergmann, Myrto Argyropoulou, Dennis Lee, Cheryl Brown, Larry Beerkircher, Ron Rinaldo, Steve Meyers, and Tyson Kade, and Nick Hopkins for their extraordinary efforts.

NED 2002

SEA TURTLE DEMOGRAPHICS AND EXPERIMENT RESULTS

This is a review of the 2002 results of the NED Experiment, in partial fulfillment of the annual reporting requirements of permit #1324. The results for the 2001 experiment can be found posted as watson1.pdf at http://www.mslabs.noaa.gov/mslabs/docs/pubs.html.



This is an outline of the presentation.

Incidental Take
NED 2001-2002

<table>
<tr><th></th><th colspan="2">Take Statement</th><th>Observed Take</th></tr>
<tr><th>Species</th><th>Total</th><th>Dead</th><th>All live</th></tr>
<tr><td>Loggerhead</td><td>415</td><td>4</td><td>242</td></tr>
<tr><td>Leatherback</td><td>301</td><td>1</td><td>235</td></tr>
<tr><td>Green</td><td rowspan="4">2</td><td rowspan="4">1</td><td rowspan="4">0</td></tr>
<tr><td>Kemp’s ridley</td></tr>
<tr><td>Hawksbill</td></tr>
<tr><td>Unidentified</td></tr>
</table>

This table shows the overall take of turtles 2001-2002 for permit #1324. To break it down by year:

142 loggerheads in 2001 + 100 in 2002

77 leatherbacks in 2001 + 158 in 2002

GENETICS

Peter Dutton

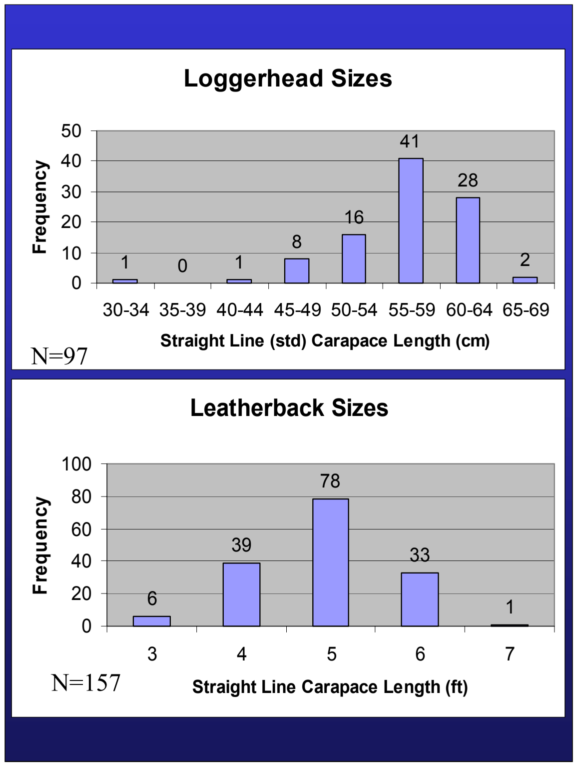
National Sea Turtle Genetics Laboratory

- **Leatherbacks (N=125)**
  - **95 sequenced thus far**
  - **No unique haplotypes**
  - **Analysis incomplete**
- **Loggerheads (N=236)**
  - **166 sequenced thus far: 9 haplotypes**
  - **Most samples were haplotypes found in common among all U.S. subpopulations**
  - **A few samples were haplotypes unique to Mexico, Dry Tortugas, N.E. Florida, or S. Florida**

In 2002 we collected biopsies from 100 loggerheads and 125 leatherbacks. These samples were shipped to Dr. Peter Dutton at the National Sea Turtle Genetic Laboratory in La Jolla, California.

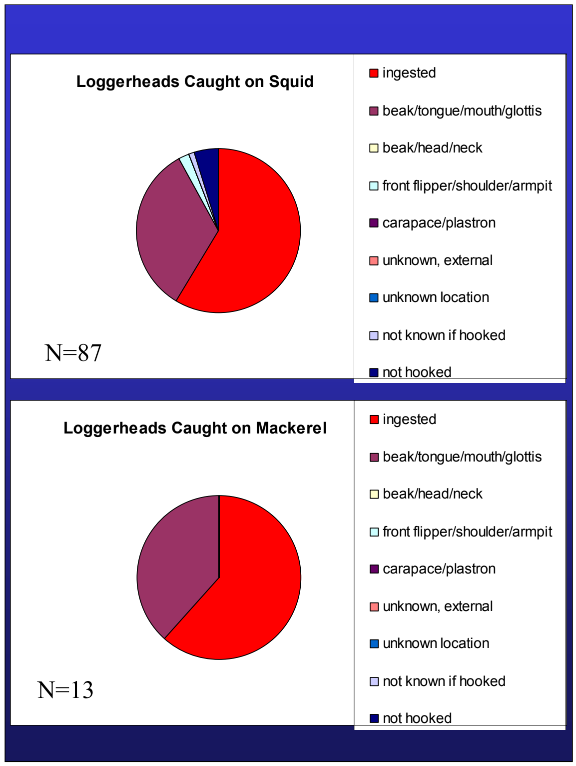
Dr. Dutton reports that of the first 20 leatherbacks sequences aligned, most are the common haplotype “A” with approximately 30% haplotype “C”. Thus far he has found none of the rare, endemic haplotypes that are found in St. Croix, USVI or Africa. The full set of mtDNA data should be done by the end of March. When they finish the large sample set from French Guyana, they will be able to do a mixed stock analysis. By summer they should also have the full set of microsatellite data and will be able to resolve the stock origins.

For the loggerheads, 166 of the 236 samples collected 2001-202 have been sequenced. Preliminary mixed stock analysis indicates the majority are from the South Florida subpopulation.

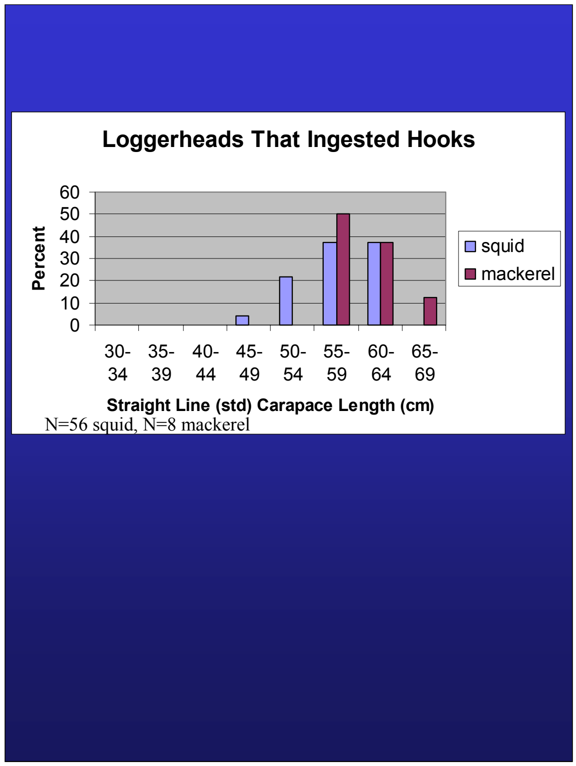


The mean size of loggerheads caught in 2002 (56.9 cm) was identical to the mean size of loggerheads captured in 2001 (56.7 cm). In 2002, turtles ranged in size from 32.4-68 cm. In 2001 the range was from 44.5 to 70.5 cm.

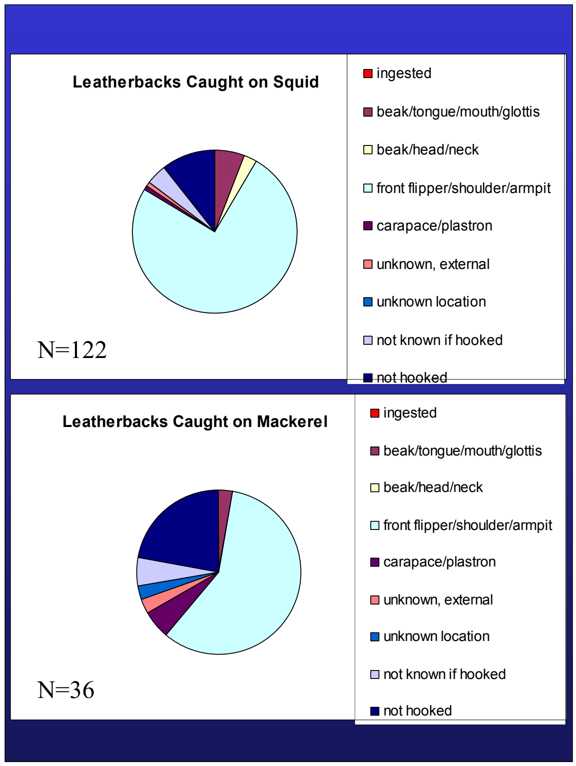
Leatherback carapace lengths were estimates as none were actually measured. Most were 4 to 6 ft in length.



A small proportion (5%) of loggerheads caught on squid were not hooked. All animals caught on mackerel were hooked, but the proportion caught in the beak/mouth/tongue/glottis increased some (33 to 38%) as did the proportion ingesting the hook (59-62%). Overall, though, there didn't not appear to be much difference in the hook location resulting from squid or mackerel bait.

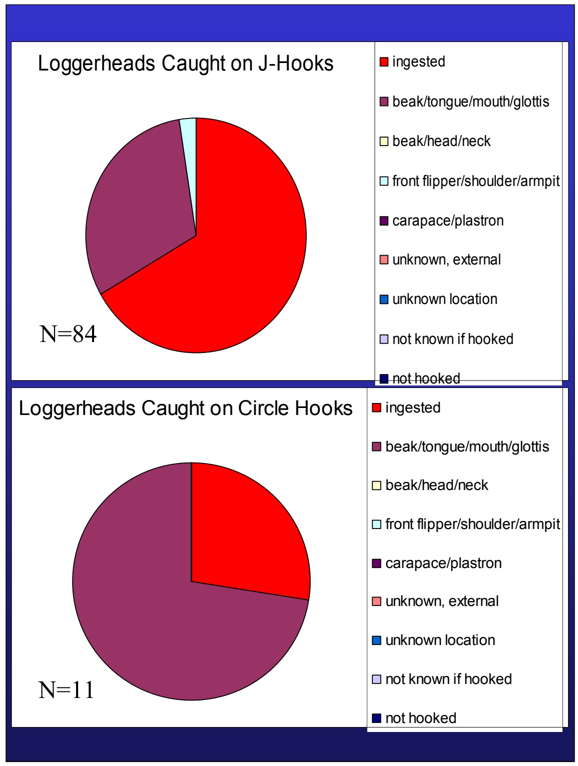


It appears that the turtles ingesting mackerel (red bars) were the largest of the turtles captures (sizes of turtles ingesting squid are shown in the blue bars), but the sample size really is too small to determine if there is size selectivity.

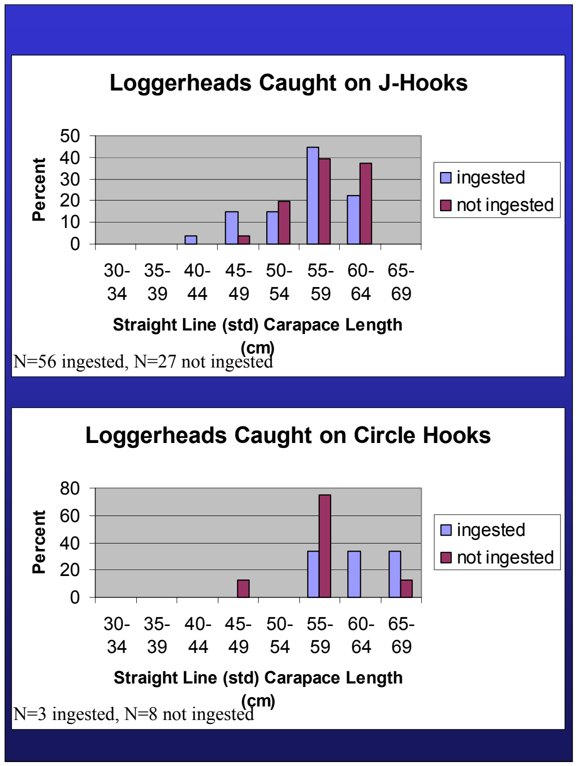


The proportion of animals not hooked, but entangled, more than doubled with mackerel as bait (from 10.6% to 22.2%). Evidently mackerel shielded the hook somewhat, but that may have been due to the hooking method. The proportion hooked in the front flippers/shoulder/armpit decreased by slightly more (75.4% to 58.3%).

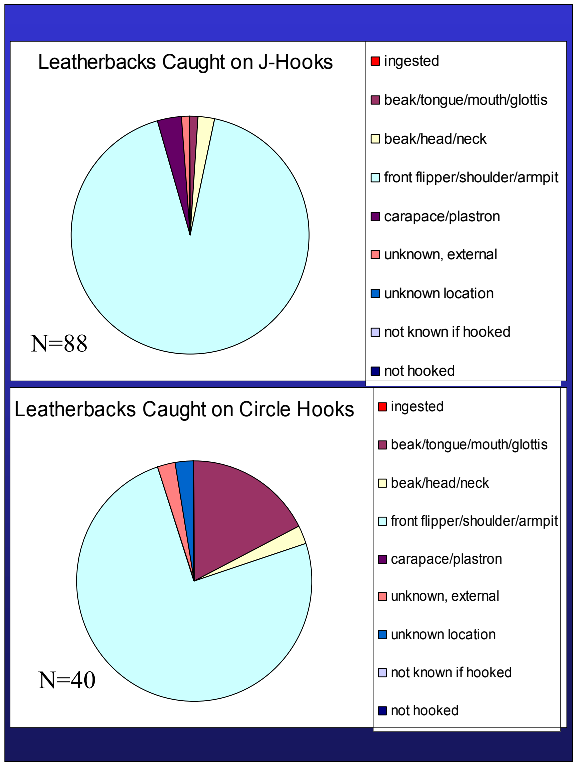
Thus, it appears that a smaller proportion of the animals caught on mackerel get hooked, and instead are caught by entanglement.



These graphs tell it all. The majority (66.7%) of loggerheads caught on J-hooks ingested the hook. The picture is quite different for loggerheads caught on circle hooks, where only 22.3% ingested the hooks. It is very clear that the majority of turtles caught on circle hooks were caught in the mouth (72.3%) instead of ingesting the hook. It is interesting to note that 3 turtles ingested circle hooks and all 3 of those were offset, not straight circle hooks. Of the 3 turtles ingesting the offset circle hook, 1 was taken on mackerel and 2 were taken on squid.



The sample size is too small to determine whether there is size selection for ingesting circle hooks, but there is some indication that the circle hooks were ingested by the larger turtles only.



Most (82% and 75%) of the leatherbacks are being caught in the front flipper/shoulder/armpit area with both the J-hooks and the circle hooks.

However, with circle hooks, a greater proportion are not being hooked in the flipper/shoulder area and instead are getting the bait into their mouth and being hooked there – all but one hooked in the mouth were caught on offset circle hooks.

The one leatherback caught on the straight circle hook in the beak/mouth/tongue/glottis was taken on mackerel.

Six turtles were caught in the beak/mouth/tongue/glottis on the offset circle hook and of those 5 were taken on mackerel.

Hooks Removed from Loggerheads

Hook Location	No	Yes	N/A	Total
Ingested	52	7	0	59
Mouth	1	33	0	34
External	0	2	0	2
Not known if hooked	0	0	1	1
Not hooked	0	0	4	4
Total	53	53	4	100

In 2001 we removed 38 (66%) of the 58 hooks in the beak/tongue/mouth; This year we removed all but 1 (3%) of the 34. This reflects an increased effort to remove hooks along with an increased appreciation for the need to remove the hooks.

In 2001 we removed none of the 79 ingested hooks. This year we removed 7 (7%) of the 59.

Hooks Removed from Leatherbacks

Hook Location	No	Yes	N/A	Total
Ingested	0	0	0	0
Mouth	2	6	0	8
External	66	56	0	122
Not Known if Hooked	0	2	5	7
Not Hooked	0	0	21	21
Total	68	64	26	158

In 2001 we did not remove the 1 hook lodged in the mouth of a leatherback. In 2002 we removed 2 (25%) of the 8 hooks in the mouths of leatherbacks.

In 2001 we removed but 20 (33%) of the 61 hooks that were external. In 2002 we removed 66 (48%) of the 132. The crew is gaining experience and consequently is being more successful at removing hooks from animals too large to be boated.

Line Left on Turtles

Loggerheads

- No line was left on 69 (69%) turtles
- Line ranging from 0.1 to 0.6 ft was left on 31 turtles; usually the line left was 0.1 ft or less (48%)

Leatherbacks

- No line was left on 96 turtles (61%)
- Line ranging from 0.1 to 40 ft was left on 62 turtles; usually the line left was 2 ft or less (48%)

LOGGERHEADS

In 2001 all line was removed from 77 (54%) of the 142 turtles. In 2002 it was removed on 69 (69%) of the 100 turtles. The amount of line remaining in 2001 was always less than 1 ft and averaged 4 inches. In 2002 the line left averaged 1 inch. Again, experience is paying off. We are leaving less gear on the animals.

LEATHERBACKS

In 2001 all line was removed from 35 (45%) of the 77 turtles. In 2002 all line was removed from 96 (61%) of the 158 turtles. Again, we are leaving less gear on the animals than before.

In 2001 as much line as 25 ft was left on the animals and the average was 4.5 ft. In 2002 the line left ranged from 0.1 to 40 ft, usually 2 ft or less.

ACKNOWLEDGMENTS

- Captains, Crew, Owners, and Managers Participating in the Experiments
- NOAA Fisheries Observers
- ARC
- John Watson, Charlie Bergmann, Myrto Argyropoulou, Dennis Lee, Cheryl Brown, Larry Beerkircher, Nick Hopkins

Acknowledgments

TURTLE HANDLING

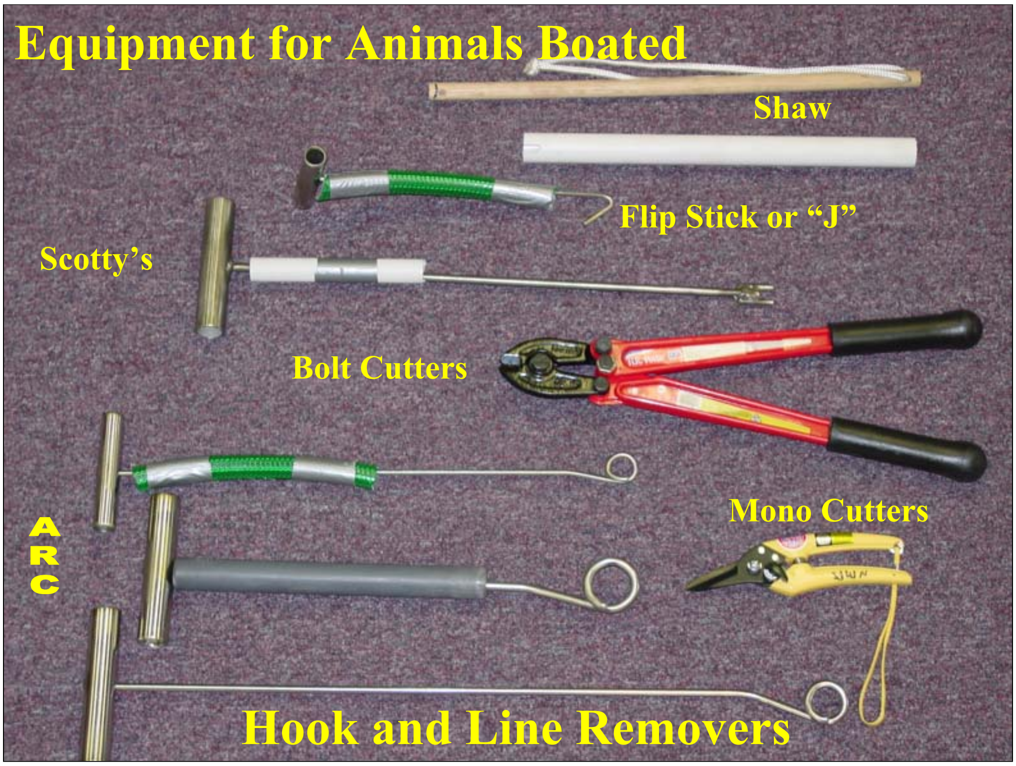
This presentation summarizes the tools and techniques used to remove line and hooks from turtles.

The observers were supplied with two types of equipment: (1) for animals not boated and (2) for animals boated. The line cutter and dehookers were used successfully on turtles and other animals, such as marine mammals and ocean sunfish.

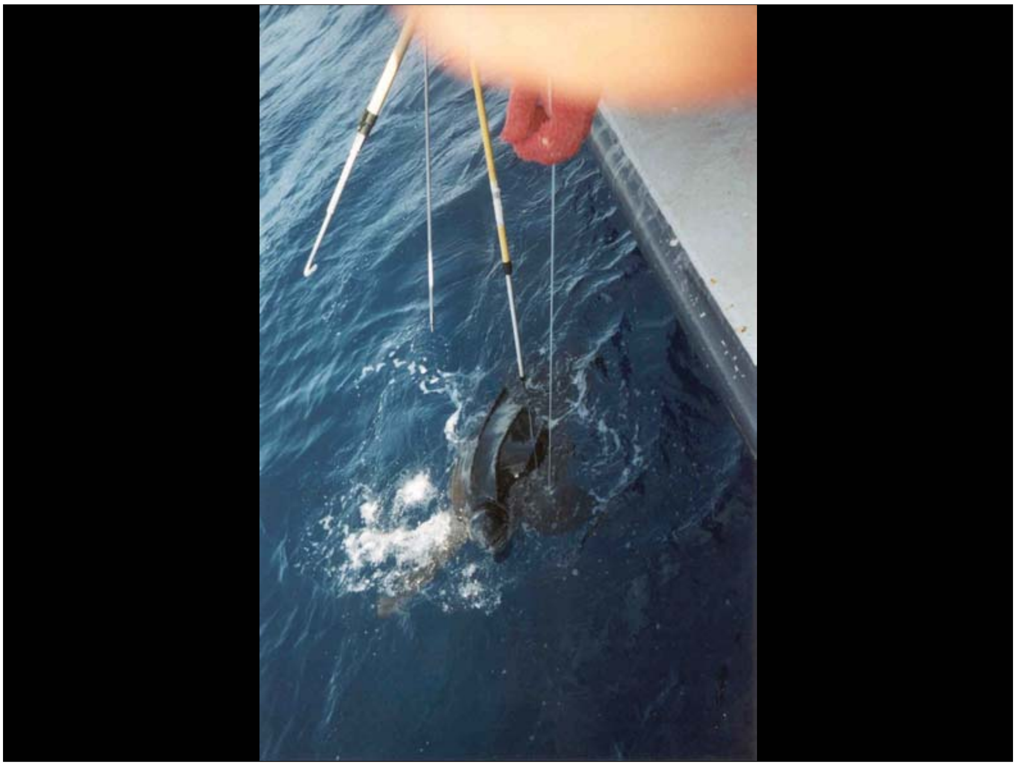
For animals too large to be boated, the vessels used the breakdown ARC Dehooker, the LaForce Line Cutter, and gaffs and poles already aboard the vessel. They also used biopsy poles. At the beginning of 2002 they were issued fiberglass biopsy poles, but they were found to be extremely flexible. Thus, in conjunction with ARC we designed a new biopsy pole by creating a pole segment with the necessary screw threads to accept the biopsy corer. This proved to be a much better tool for collecting the samples.

Many of the vessels participating in 2002 had experience removing gear from these turtles from the 2001 experiment. Others were new to the equipment. There was a learning curve, but with time the success rate improved.

The observers were provided a variety of tools to open and gag open the mouth so that hooks could be removed or line cut. The brush wood handle was the only tool used in 2001 and it was used by a number of observers in 2002. Generally, when the turtle has a hook in its mouth, opening the mouth was not a problem. Some observers attempted to use the canine mouth gag.



These are tools to remove hooks and line. Not pictured are the stainless needle nose pliers, which were reported to work well. The curl of the bite protected ARC dehookers were generally too large to fit into the esophagus of the turtles. Only the smallest would fit. The bolt cutters were too large to cut the eye of the hook in the back of the mouth; we need to find bolt cutters with more of a needle nose. These devices were used on turtles and on other animals, such as sharks.



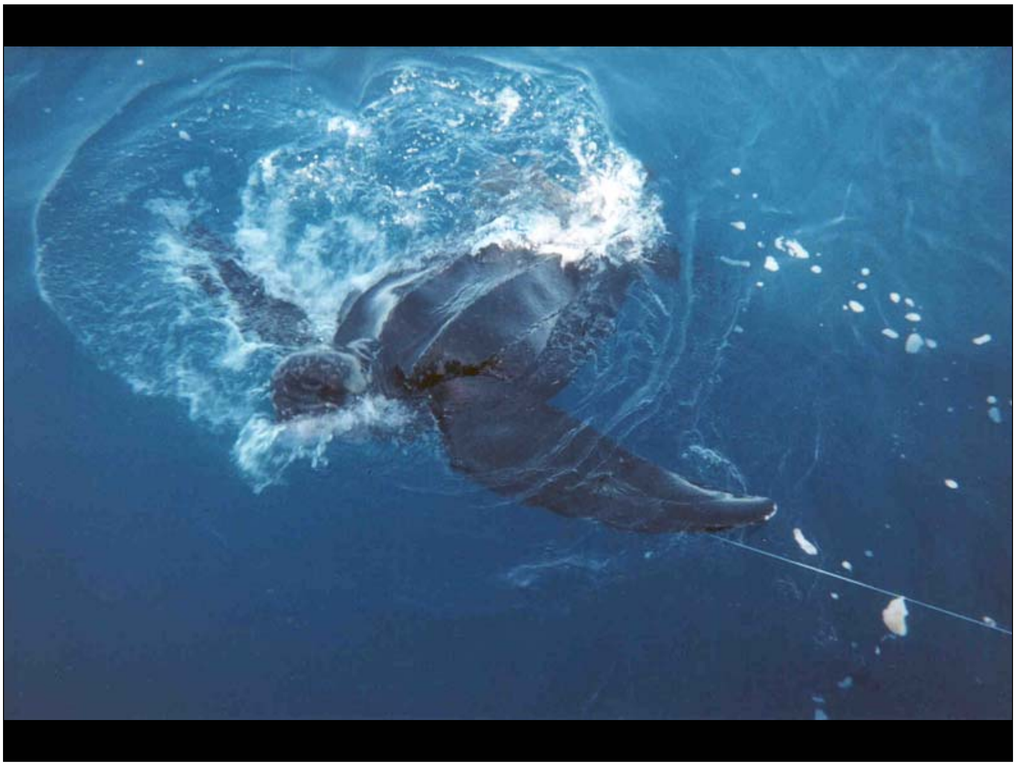
Some leatherbacks were both hooked and entangled. The removal of line and the hook required the coordination of at least 3 crew members. The gangion being held with a gloved hand, while other crew members used the line cutter and the dehooker and another took a biopsy sample.

(1) A gaff

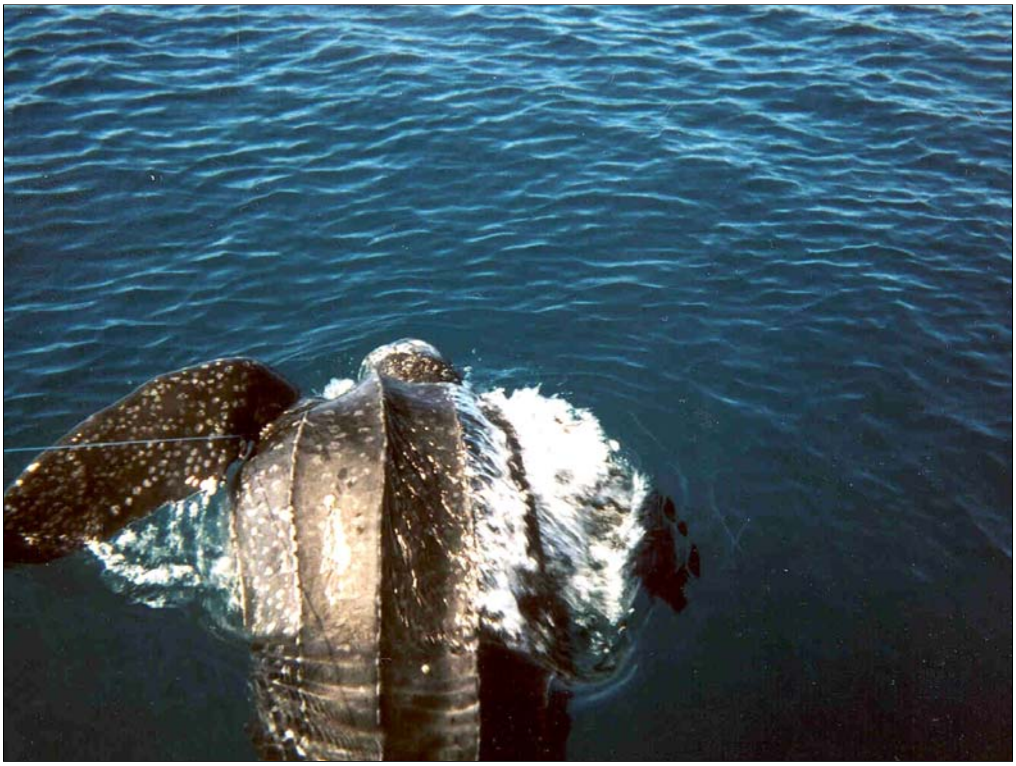
(3) The fiberglass biopsy pole

(4) The LaForce line cutter

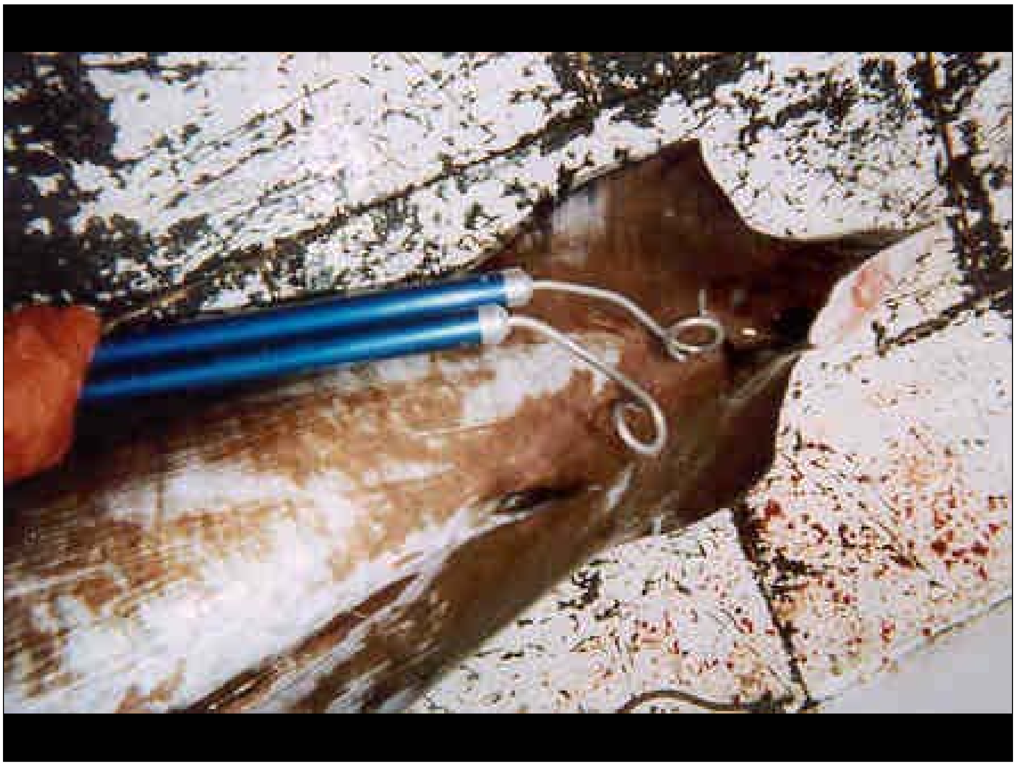
The line cutters were also used to release other animals such as marine mammals and ocean sunfish.



Hooks lodged in the armpit and hooks lodged on the side away from the boat presented the greatest problems for removal. ARC has developed a technique referred to as the inverted “V”. Once the observers were briefed about this method, success in removing hooks from entangled turtles as well as when the line was running underneath the animal improved.

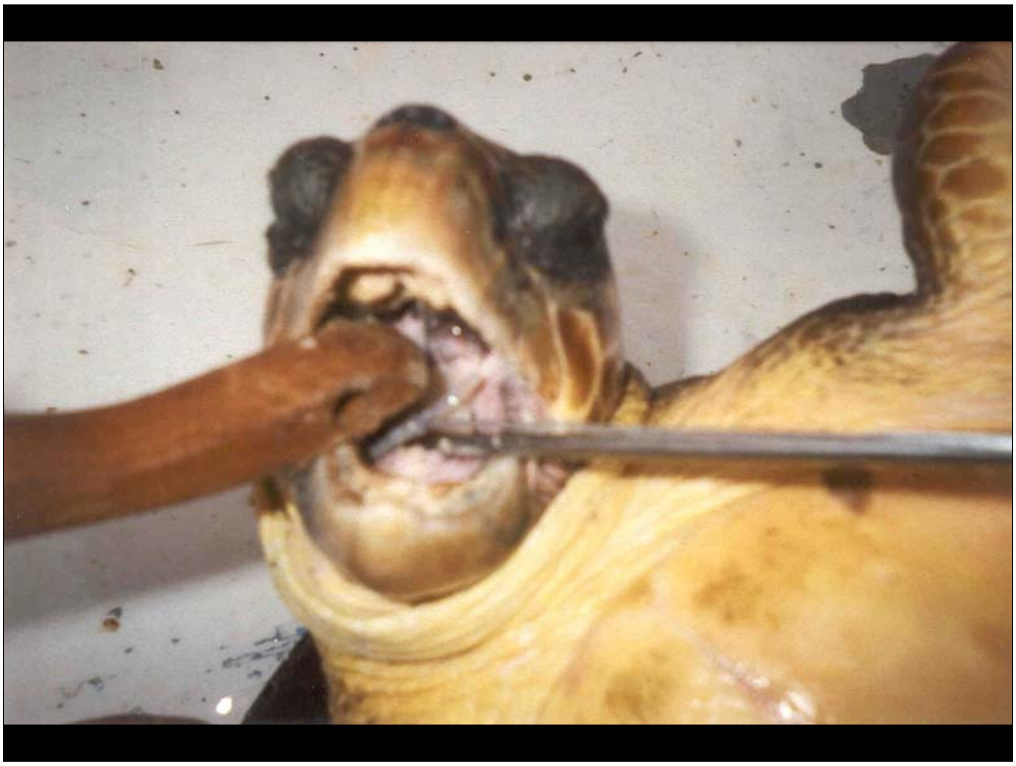


If the line wraps under the flipper, one cannot follow the line down to get the pigtail on the hook. This is a situation requiring the use of the inverted “V” technique.



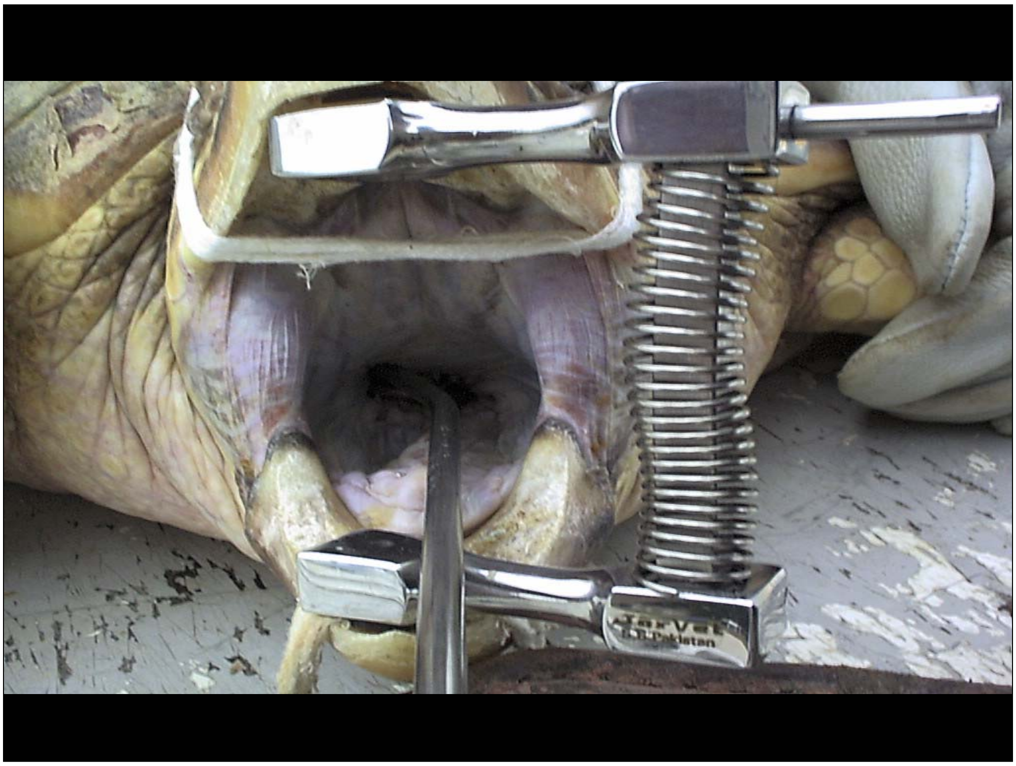
Trying to use the dehookers to leverage the turtle to get the pigtail on the hook frequently resulted in bent dehookers. ARC has worked on the design as well as developed a technique to deal with the situation of hooks in the armpit, wraps of line before the hook, etc.

Turtles brought on board usually were placed on tires and photographed with the gear still attached. Most boats had a variety of sizes of tires onboard.



While we gave observers a diversity of tools to open the mouth and keep it open, the turtles generally had their mouth open when there was a hook inside. One of the most commonly used mouth gags was the wooden brush handle.

A few observers used the canine mouth gags successfully and had wonderful things to say about them. In this situation, the hook had been ingested, but the observer (with a flashlight in hand) could see the insertion point and using the smallest ARC dehooker removed the ingested hook.



This shows how easy it is to get a dehooking device into the mouth with the canine mouth gag in place.

The ARC dehookers were well liked and used on animals other than turtles. Other styles tried were Scotty’s dehooker and the flip (J) stick.

Circle hooks were difficult to remove.

We didn’t really get a chance to fully test the mouth openers. But, the canine mouth gags appear promising for allowing observers to see well enough to remove ingested hooks.

Suggested Changes

- An ARC dehooker with the larger gauge wire but a small diameter curl, with PVC sleeve
- Stronger long-handled dehooker
- LaForce line cutter integrated into ARC pole system
- Needle-nose bolt cutters

All these have been implemented, except one. We still are searching for stainless needle nose bolt cutters.

Post-Hooking Survival Pilot Study

Sheryan Epperly, Alan Bolten, Eric Prince,
Chris Sasso, Carlos Rivero

This presentation details the results to date of the pilot post-hooking survival study.

PAT TAGS RELEASED IN 2001

	Controls				Treat-ment
	Floating Free of Turtle	Entangled	Flipper Hooked	Mouth Hooked (lightly)	Ingested
Azores	4			2	1
NED		2	2	3	9

This shows the number of tags deployed in 2001. Loggerheads are the only species being investigated.

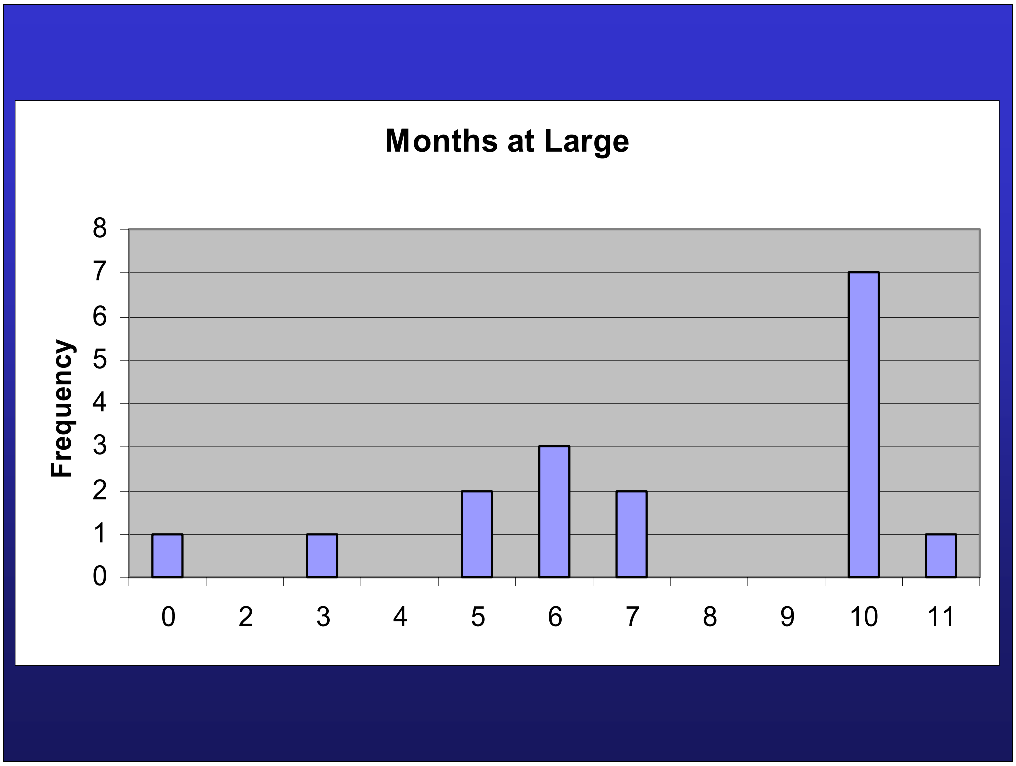
PREMATURE RELEASE CRITERIA

- PAT tag will release before designated release date if depth remains constant +/- 2 m for 96 hours; no outliers are ignored
- Premature release detection was enabled on NED releases but not on Azores releases
- Each tag tether had a RD-1500 device that would sever the tether at approximately 1500 m

These are the premature release criteria used for the 2001 deployments in the NED.

AZORES DRIFTERS (N=4)

- All were deployed on September 1, 2001
- Premature release function was not enabled
- All began transmitting on July 15, 2002 (the programmed pop-off date)
- After being at large for 10.5 months, we received an average of 38% of the histograms collected



This shows the duration of deployment for each tag on a turtle. All were supposed to be deployed for at least 9 months.

0 months: fate of 1 turtle could not be determined

3 months: 1 could not be determined

5 months: 2 could not be determined

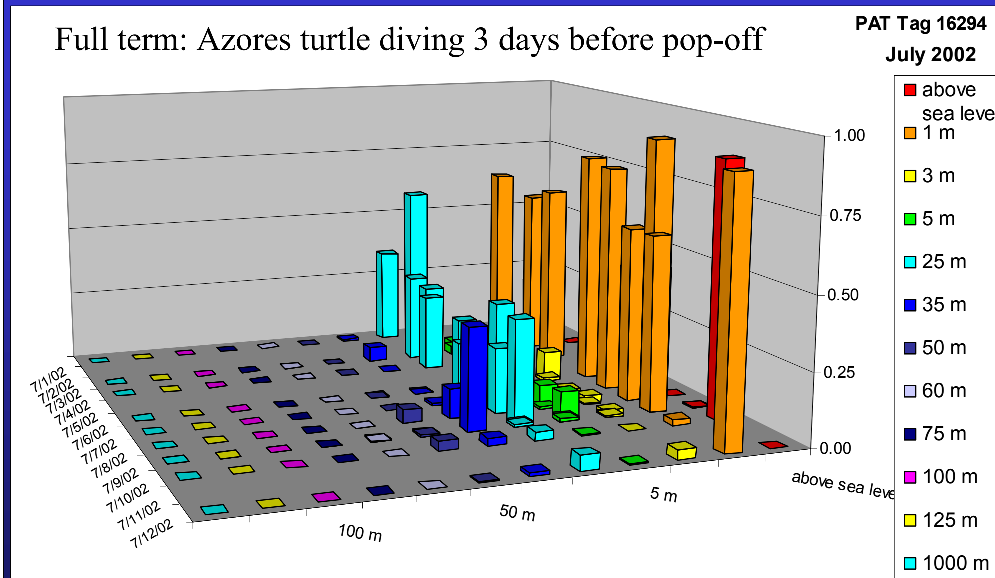
6 months: 1 died and 2 could not be determined

7 months: 2 could not be determined

10 months: 3 survived (2 from Azores) and 4 could not be determined

11 months: the one survived

Premature Release Function Not Enabled



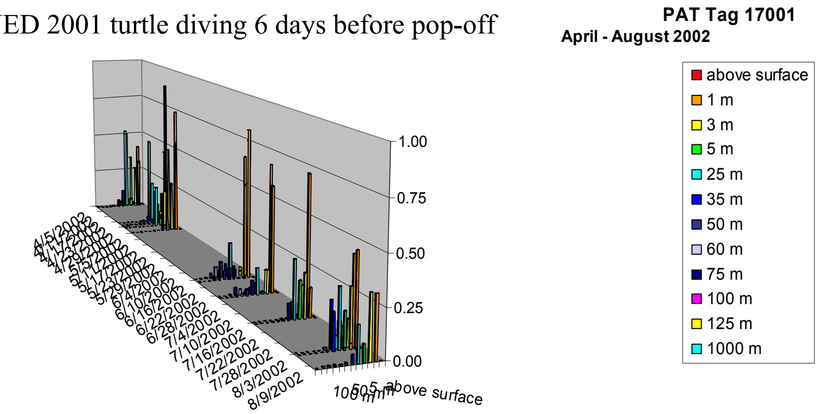
Histograms not received for 2 days prior to programmed pop-off

This is an example from a turtle that survived to the programmed pop-off date.

Programmed pop-off date was July 15, but within 3 days of pop-off, the turtle was diving. Presumed alive on July 15. Premature release was disabled.

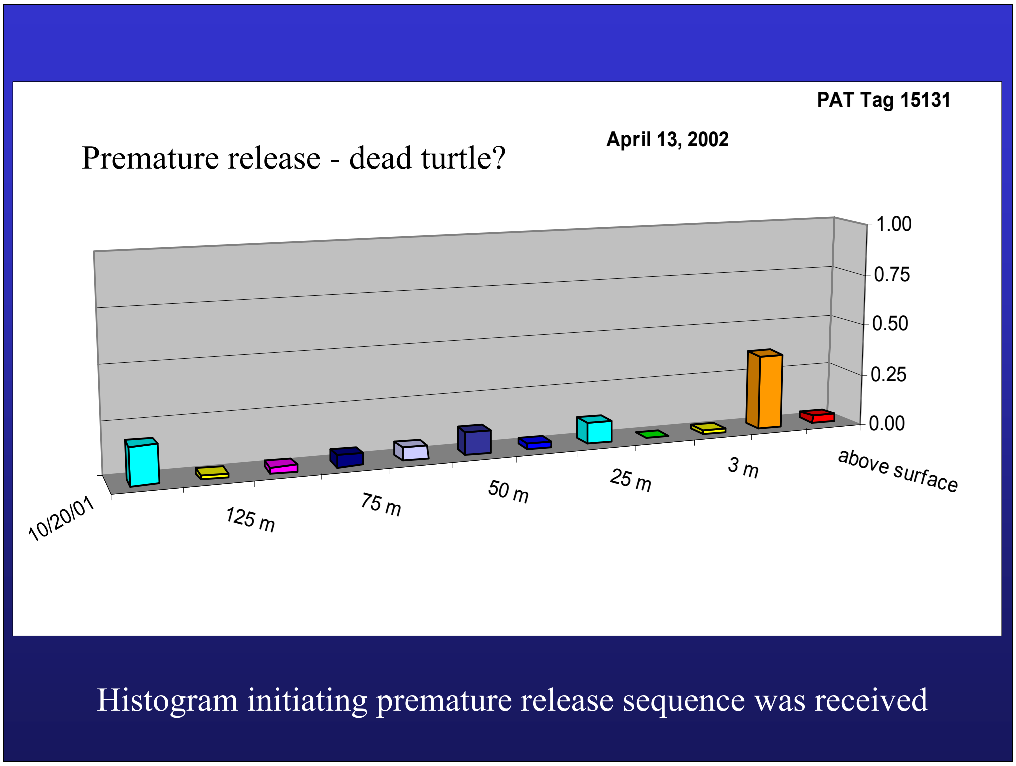
Premature Release Function Enabled

Full term: NED 2001 turtle diving 6 days before pop-off

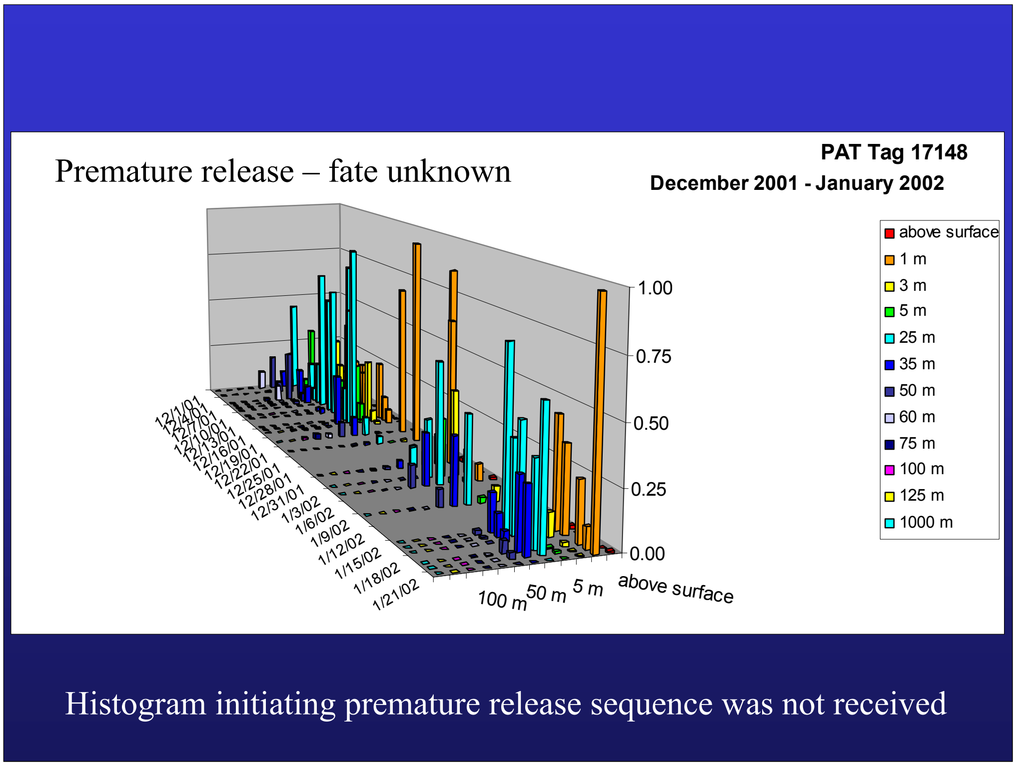


Histograms not received for 5 days prior to pop-off

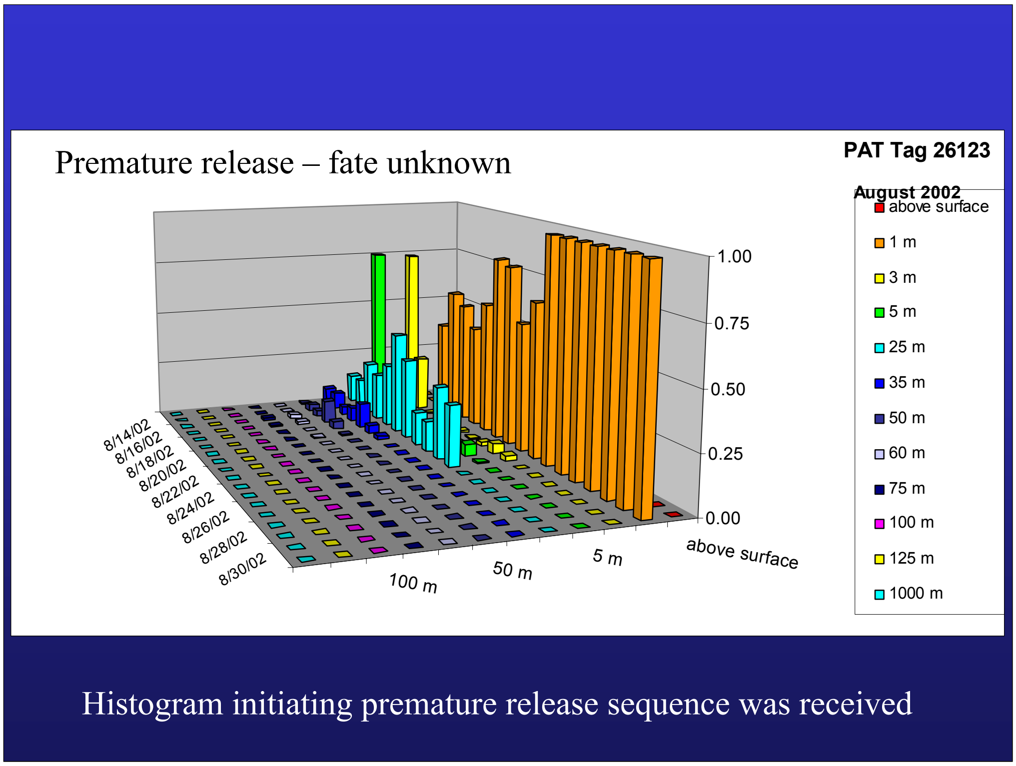
This is an example of a turtle that survived to its pop-off date.



This is an example of a turtles that we believe died. The turtle spent uncharacteristically much time at depths > 125 m (no PDT to identify deepest depth). No status record was received to indicate if RD-1500 triggered; likely that it did. We had poor reception of the data – records were received only on April 26. Likely that premature release sequence began on April 13 and tag released 4 days later on April 17 and began transmitting.



This is an example of a premature release, but we cannot determine the fate of the turtle. The premature release sequence began in am of 1/21/2002, but we only received the histogram for that day for the pm (after sequence began). Prior to premature release sequence turtle was diving. Was this an acute event (e.g., predation) or tag attachment failure?



This is another example of a premature release. This tag was deployed in 2002 (note that the premature release criteria had been changed). Again we cannot determine the fate of the turtle. We did receive the histogram for the time period during which the premature release sequence was initiated. Turtle was only at large for about a week, before the 8 day premature release sequence was initiated. Once the tag began transmitting, it was almost 2 weeks later before there was a good ARGOS position associated with the transmissions. There is no indication that the turtle or tag plummeted to depth and triggered RD-1500. Was this an acute event (e.g., predation) or a tag attachment failure?

TURTLES THAT WERE ENTANGLED, HOOKED EXERNALLY, OR LIGHTLY HOOKED

	Failed to Transmit	Mortalities	Undetermined (Premature Releases)	Survivals
NED 2001 (N=7)	1 (14.3%)	1 (14.3%)	3+1 (57.1%)	1 (14.3%)
Azores (N=2)	0	0	0	2
Total (N=9)	1 (11.1%)	1 (11.1%)	4 (44.4%)	3 (33.3%)

This summaries the information to date on the turtles that were but lightly impacted by the interaction: 1 tag failed to communicate at all, 1 died (illustrated before: 15131). We could not determine fate for 4: 3 because we didn't receive the histogram associated with the initiation of the premature release sequence and 1 we did receive but could not ascertain the cause of premature release. 3 turtles survived until the programmed pop-off date.

TURTLES THAT INGESTED HOOKS

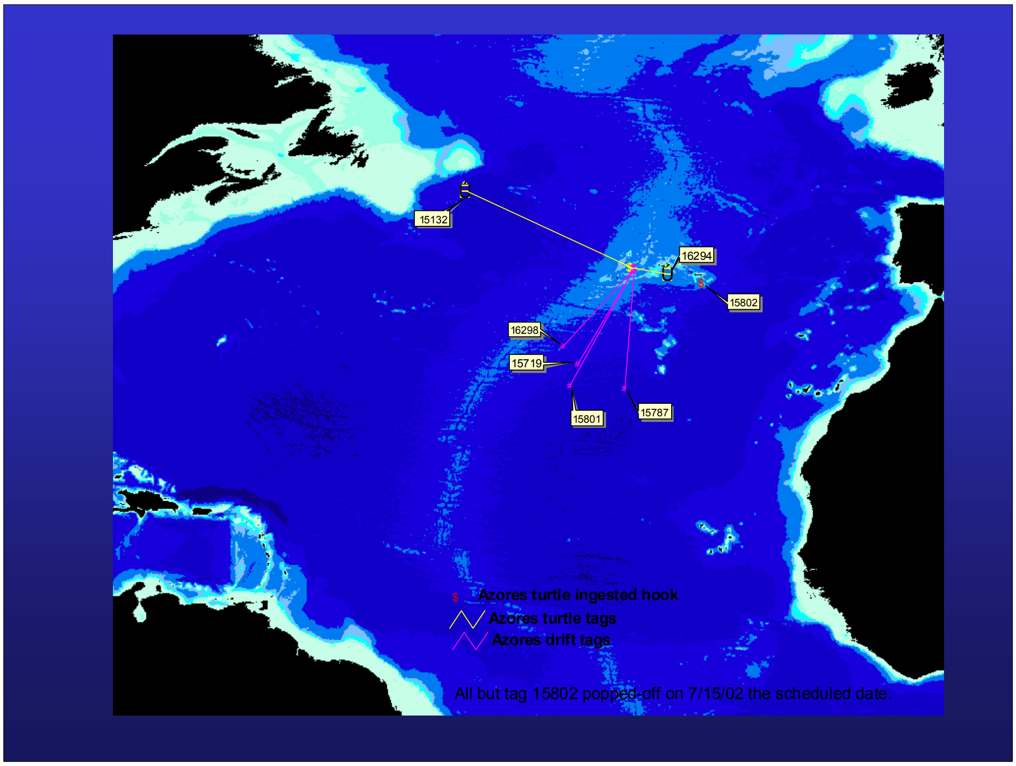
	Failed to Transmit	Mortalities	Undetermined (Premature Releases)	Survivals
NED 2001 (N=9)	5 (55.5%)	0	3 (33.3%)	1 (11.1%)
Azores (N=1)	1 (100.0%)	0	0	0
Total (N=10)	6 (60.0%)	0	3 (30.0%)	1 (10.0%)

This summaries the information to date on the turtles that had ingested the hook: 6 of 10 failed to communicate. There were no obvious mortalities. We could not determine the fate of 3 because we didn't receive the histograms associated with the initiation of the premature release sequence. 1 survived to pop-off date. With the assistance of Wildlife Computers, we have ruled out transmitter failure. The failure of tags on turtles that ingested the hook must be somehow related to something inherent in the types of turtles transmitted. We suspect that they are more susceptible to predation – an acute event.

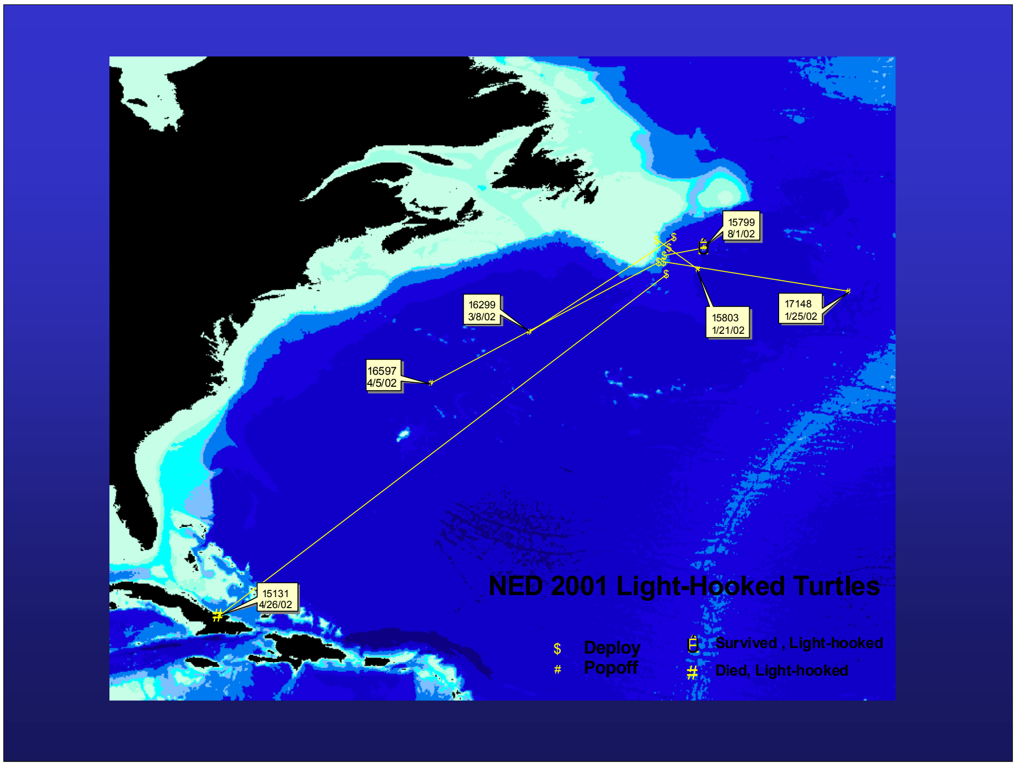
NED 2002 RELEASES

- Premature release criteria were modified for NED 2002 deployments: the criteria required an 8 d period at a constant depth (4 days in 2001 deployments)
- Tags were set to collect only 1 histogram per day (2/d in 2001 deployments)
- 6 PAT tags released in 2002: 1 entangled, 1 hooked in shoulder, and 4 hooked lightly in beak/tongue/mouth
- May 25, 2003 is the programmed pop-off date
- One tag popped off after 17 days at large (9 on the turtle); turtle status is undetermined

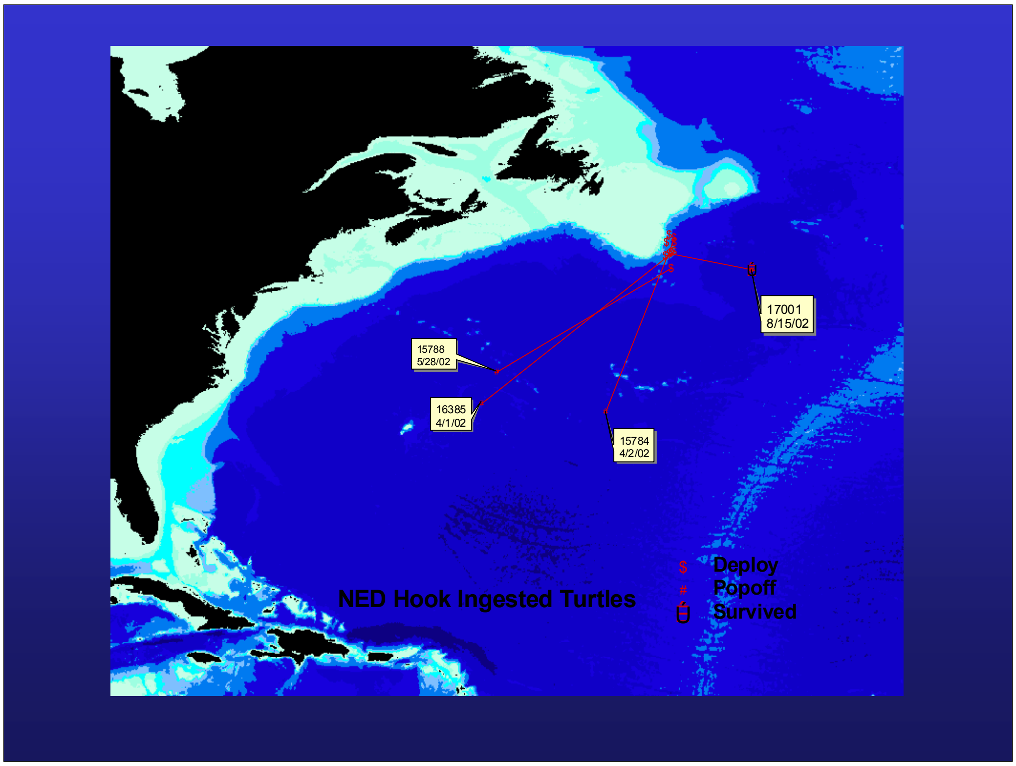
Certain parameters were changed for the 2002 deployments in order to improve the reception of unambiguous data from the tags.



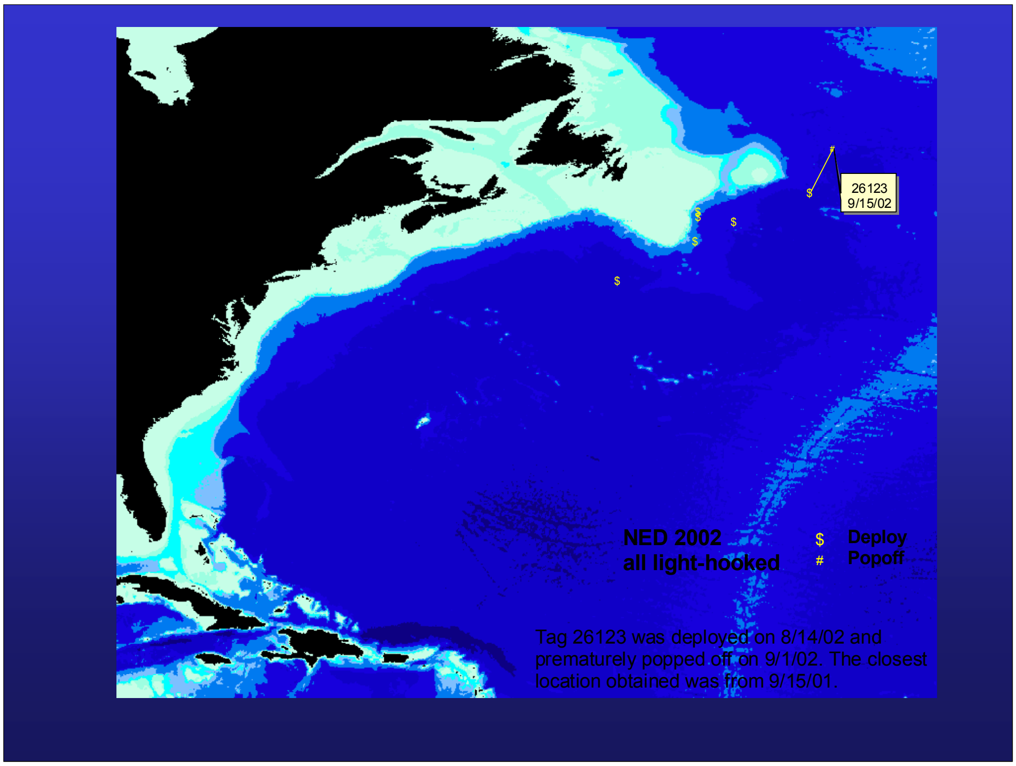
This shows the tags deployed in the Azores. Note that the positions mark only the release location and the pop-up locations. The lines between these point to not indicate the track of the turtle. Note that the 4 drifters popped-off to the south, that the tag on the turtle that ingested the hook never communicated, and that the two on lightly impacted turtles showed very different patterns. One of those popped-off on the Grand Banks. Wherever that turtle was in March, it was in cold water. Time at depth histograms and PDT data indicate that the turtle was cold stunned, floating on the surface for many days. But, it recovered and began diving. The tag popped-off as programmed 4 months later. We suspect that had the premature release criteria been enabled, the tag would have been release prematurely when the turtle was floating on the surface.



This shows the deployment of tags on turtles of the Grand Banks that had been but lightly impacted by the interaction. One tag never communicated. The turtle that went to the coast of Cuba died. One turtle was on the Grand Banks when its tag popped off on the programmed date. The fate of the others is unknown.

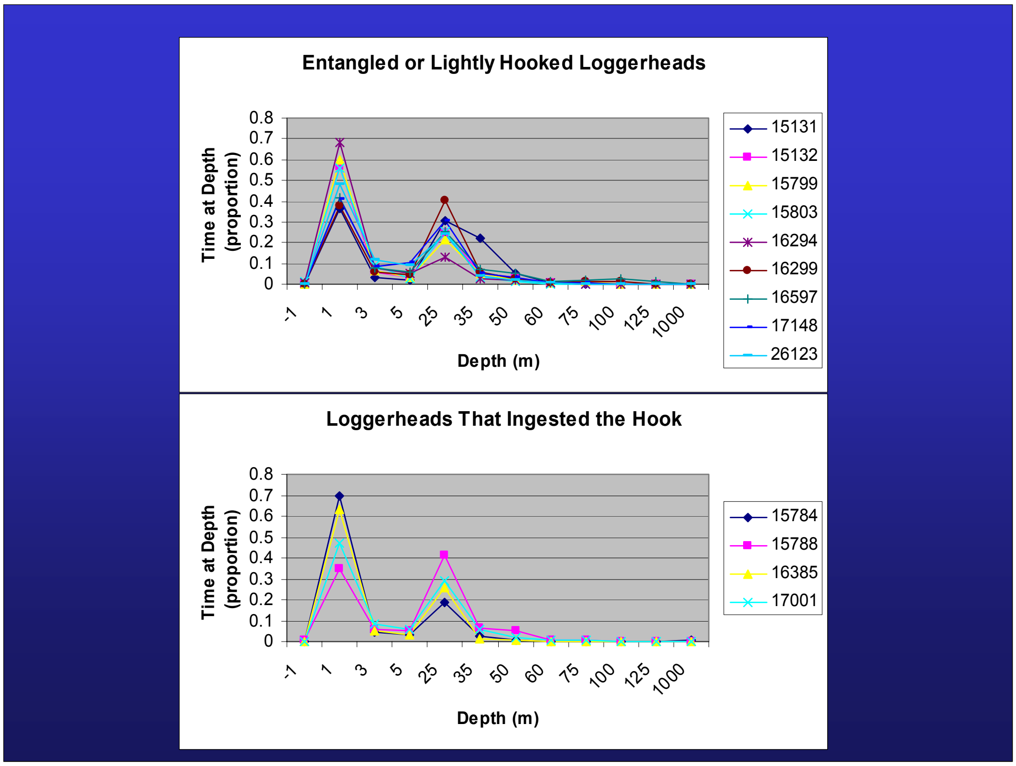


This shows the deployment of tags on turtles of the Grand Banks that had ingested the hooks. Note that 5 of 9 tags failed to communicate. One turtle survived and the fate could not be determined for the other 3 tags/turtles.



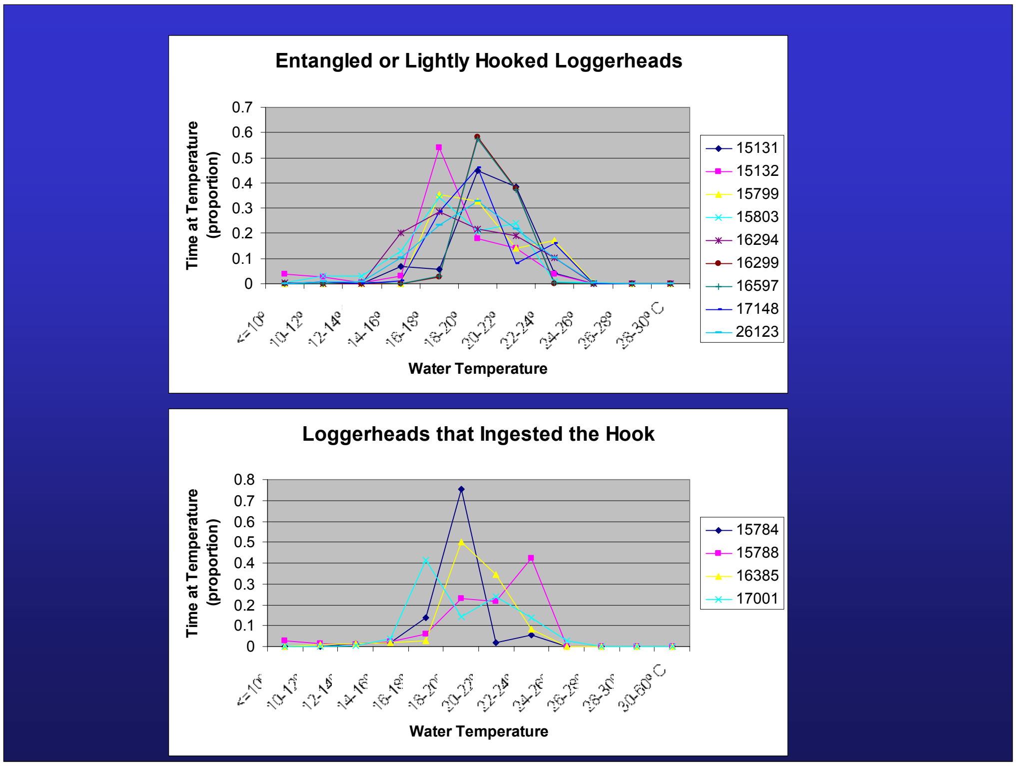
Six tags were deployed during 2002. One remained on the turtle for just over a week. We received all the histograms (1 per day) but could not determine cause of premature release.

Premature release at surface a short distance NE of release site; no deep dives > 600 m; deepest dive 72 m; temps 16-23 deg C; due to short time at large, all histograms were received; critical t-d histogram received - nothing unusual.; a tag attachment or pin failure or an acute event such as predation



As has been described previously, oceanic turtles exhibit a bimodal depth distribution: near surface and 25-35 m. Azores turtles behaved the same as NED turtles. For those tags transmitting, turtles that ingested the hook showed the same bimodal depth distribution as entangled/lightly hooked turtles.

The one turtle that was found proportionally at more deep depths, #15131, was the turtle that moved in to nearshore waters off Northern Cuba and also was the one that died.



Turtles are poikilotherms and must avoid very cold water. Turtles were found in waters as cold as 2-5 deg C (the cold stunned turtle from the Azores), but generally spent most of their time in wates 14-24 deg C. Azores turtles behaved the same as NED turtles.

PAT TAG IMPROVEMENTS

- **Premature Release**
  - Stronger pin in PAT tag since 2002
  - The next release of PAT software will be able to report if the attachment pin is broken
  - A subsequent release of the PAT will be able to determine if the PAT is dry and immediately initiate the transmission protocol
- **Improved quality of data received**
  - Instituted changes to manufacturing techniques in 2002 that improved the number of uncorrupted messages received by ARGOS
  - A future revision of PAT will include a conductivity sensor so that transmissions are initiated as soon as the antenna is out of the water.
  - R&D to implement our request to give a higher transmission priority to the histograms and PDTs that were collected 1 to 2 weeks prior to the premature release event

There are a number of improvements that are being considered to increase the probability of receiving unambiguous data.

ACKNOWLEDGMENTS

- Captains, Crew, Owners, and Managers of Vessels Participating in NED Experiment
- NOAA Fisheries Observers
- Brian Riewald
- Lisa Csuzdi, Myrto Argyropoulou, Joe Serafy
- Staff of Wildlife Computers

What Next?

Is there a reason to continue a post-hooking mortality study?

- No, not if the U.S. fishery quickly moves to circle hooks and we are asked to look at historical (J-hook) fishing practices
- Yes, if we are looking at post-hooking survival using yet-to-be implemented fishing practices
- Yes, if it is necessary to demonstrate the reduction in mortality between ingested vs mouth-hooked or externally hooked animals in order to export the technology internationally
  - Where would we get the animals? – likely not from the U.S. fishery since likely they won't be using J-hooks

Pelagic Ecology of sea turtles and management strategy for longline fisheries

Stephen J. Morreale, Cornell University
Cheryl Ryder, Northeast Fisheries Science Center

Real-time Satellite Telemetry
Project Report March 2003

The objective of this study is to use real-time satellite telemetry to provide data on the ecology of pelagic stage loggerhead turtles on the Grand Banks, where they interact with U.S. pelagic longline fisheries. It is intended that the information stemming from this research will provide crucial information to contribute to an effective NMFS management strategy to reduce, prevent, or mitigate the rate of bycatch of sea turtles in longline fisheries. This is a portion of a larger collaborative study, and as such, is intended to provide complementary data, especially to those being collected by PSAT satellite transmitters on the same group of turtles.

Prior to the longline fishing season of 2002, as part of a series of workshops, a cadre of NMFS observers was trained in details of satellite telemetry, turtle biology, and logistics of selecting and processing the turtles that would be brought aboard the longline vessel. The workshops, which were held in Miami, were sponsored and arranged by the Southeast Fisheries Science Center. Through in-depth discussions and training sessions, observers were counseled in the proper handling of turtles, and the necessary data collection. This was followed by detailed hands-on instruction sessions on the exact methodology of satellite transmitter attachment, using a turtle carcass and old transmitters.

Materials and Methods

The attachment method selected for the real-time transmitters was a one-point attachment, through a 1/4" hole drilled in the overhanging edge of the posterior-most scute of the carapace (Fig.1). This quick process is well-suited for the rapid attachment of a buoyant transmitter, which trails along behind, in the slipstream of the turtle. Furthermore, using a short flexible lanyard for attachment enables the transmitter to stand upright and transmit signals to a passing satellite as the turtle rises to the surface to breathe (Fig. 2).

Transmitters were housed within a package designed for simple and efficient attachment to turtles on the deck of a ship at sea. The transmitter housings were slightly buoyant, hydrodynamic, and crush-proof at depths in which turtles are normally active. The resultant package is torpedo-shaped, slightly buoyant, and designed so the antenna stands upright from the dorsal surface as the transmitter trails along passively behind the turtle (Fig. 3.)

The transmitter model chosen for real-time monitoring was a satellite-linked time-depth recorder, type SDR-T16 (Wildlife Computers, Redmond, WA 98052), which serves as the controller for an ST-16 Argos transmitter (Telonics, Mesa AZ). This style recorder combines the ability to monitor depth, position, surfacing activity, and diving profiles with the ability to transmit all of these data to passing satellites on a near-real-time basis.

In July 2002, just prior to the beginning of the fishing season, transmitters were distributed to fishing vessel captains and NMFS observers, to be included in their turtle research kits aboard the vessels. Initially, two real-time transmitters each were distributed to each of four observers, and a fifth observer received a single transmitter. Since the real-time transmitters were complementary to the PSAT transmitters, the plan of attachment was for the observer to alternate, using a PSAT transmitter on one turtle and a real-time transmitter on the next captured turtle.

During the course of the season, real-time transmitters were attached to five juvenile loggerheads that were incidentally captured in the experimental longline fishery. All of these turtles were lightly hooked, shallowly in the anterior part of the mouth (see observer data for full details). The attachment process reportedly went smoothly, even sometimes on a pitching deck, and all five turtles were active and apparently healthy upon return to the water.

Results Summary

Location data - The first two real-time satellite transmitters (labeled "Jimmy1" and "Jimmy2") were attached to loggerheads from the same vessel on 15 and 16 August 2002, respectively. The release location of Jimmy1 was approximately Lat. 46^{o} 08' N and Lon. 41^{o} 01' W, a position nearly 54 Nmi east of the southeastern tip of the Flemish Cap (Fig. 4). Over the course of the next 29 days, Jimmy1 moved generally southwards, meandering over a course that carried it much farther than its net distance of approximately 442 Nmi from its release location (Figs. 4-5).

The second transmitter, Jimmy2, was released near Lat. 47^{o} 26' N and Lon. 42^{o} 11' W, about 11 Nmi east of the Flemish Cap and nearly 127 Nmi north of Jimmy1. This turtle's early movements took it in clockwise loops around the region of the northern Flemish Cap, before it also headed generally southeastwards for the remainder of its 31 day track (Figs. 4-5). It was at this point, a net distance of 210 Nmi from the release location, that the transmitter reported its last diving data (Fig. 5). It has not yet ben determined whether this transmitter detached from the turtle, or merely stopped sending auxiliary data. Nevertheless, over the next two weeks the transmitter continued to move more than 200 Nmi farther along a southern track that was similar to the previous turtle's route. At one point, although these paths were separated by more than 4 weeks, the routes passed within 17 Nmi of the same location.

A third transmitter, Jeff1, was attached to a loggerhead more than 500 Nmi farther east on 23 September. The release location near Lat. 42^{o} 59' N and Lon. 52^{o} 21' W, was nearly 240 Nmi south of Avalon Peninsula, Newfoundland, on the western fringe of the Grand Banks (Fig. 5). Soon after its release, this turtle began an arching curve southwestward, and thereafter continued on a meandering path along the edge of the continental shelf (Fig. 6). Over the entire 40 day monitoring period, Jeff1 exhibited a net movement of 203 Nmi southwest of the original release point.

The fourth and fifth transmitters were released in October from the same vessel, and both on the eastern fringes of the Grand Banks (Fig. 6). Patrick3 was released on 12 October, 31 Nmi east of the southeastern tip of the Flemish Cap, near Lat. 46^{o} 30' N and Lon. 41^{o} 35' W. Similar to the previous turtle tracked in the same area, this turtle began swimming in loops, one counterclockwise, the other clockwise, moving a great deal more than its calculated net movement of 88 Nmi. It is possible that such circular paths represent search patterns, especially for an animal trying to orient to some environmental cue.

The following week Patrick2 was released closer to the Tail of the Bank region of the Grand Banks, near Lat. 44^{o} 32' N and Lon. 47^{o}18' W (Fig 6). This turtle headed mainly southeastwards to the Newfoundland Basin, toward the same general area as two of the previous turtles of its cohort. At the finish of its 20 day track, the Patrick2 moved a net distance of 200 Nmi from its original site of capture and release.

Bathymetry - An potentially important environmental feature in the realm of these pelagic loggerhead turtles is the bathymetric profile in their area. In the case of these recorded movements, however, there was no obvious influence of ocean depths on the locations of the turtles (Fig 6). Overall, the depths over which the turtles moved ranged from 2310 m to 5115 m. Jimmy1 and Jimmy2 moved quickly over a sea floor rise, but mostly remained in deeper waters of the Newfoundland Basin. For the most part, there seemed to be a great amount of spatial auto-correlation, with regard to the turtle locations and the depth of the water beneath them. It is pretty clear that all of these depths are well beyond the physiological limits of diving for these juvenile turtles, and they were not directly selecting their locations based on bathymetry alone.

Water column - Perhaps the single most important information next to geo-referenced positions of the turtles is their activity with respect to position in the water column. Without knowledge of the depth profiles of turtles it would be very difficult to tease apart or properly relate the turtles' movements with environmental factors such as bathymetric characteristics or water temperature.

Indeed, the summaries of the percent time spent by all the turtles at various depths throughout the water column show very clearly that these young pelagic loggerheads are not shuttling to and from the bottom (Figs. 7-9). Rather, the five turtles cumulatively spent from 50% to 67% of their time in the upper 2 m of the water column. Moreover, they spent very little time at depths below 70 m, and only occasionally ventured deeper than 100 m. The confinement of activity to the upper 10% of the water column makes it highly unlikely that water depth is directly influencing turtle biology in the waters surrounding the Grand Banks. Any associations with water depth are likely indirect, such as the relationship between the continental rise and the North Atlantic Current.

There was no apparent seasonal pattern in depth usage patterns. Instead, the deeper dives recorded in September and October reflect inherent differences among individual turtles (Figs. 8-9). As an illustration, Jimmy2, Patrick2, and Patrick3 were never recorded diving deeper than 70 m; Jimmy1 made excursions down beyond depths of 130 m in both August and September; and Jeff1 was the deepest diver with dives to as deep as 248 m. The location of the turtles did not obviously affect the diving depths, but a more detailed analysis at the scale of the individual turtle may be warranted.

Sea surface temperature - Water temperatures appeared to have a direct influence on the movements of the turtles. All told, the five turtles traveled through water temperatures ranging from 14^o C to 25^o C. When turtles encountered water temperatures at the lower end of this range, they appeared to be stimulated to move. Often these movements took on a meandering or circular path, which gave the distinct appearance that young loggerheads were orienting to thermal cues (Fig.10). The obvious circular paths exhibited by Jimmy2 and Patrick3 both were movements made initially from 17^o C water, and immediately into cooler water. As they encounter the cooler water, they continued circling until warmer water was reached. For these, and the other meandering turtles, once the water temperatures started to increase, their paths tended to straighten out. Upon last contact, Jimmy2 was in water temperature of higher than 20^o C, Patrick2 was in waters warmer than 22^o C, and Jimmy1 and Jeff1 made it to waters with temperatures exceeding 24^o C. It is very likely that temperatures are extremely important to many aspects of the ecology of these pelagic juveniles, and it is likely also that this could be the means for predicting where and when turtles are in the Grand Bangs region.

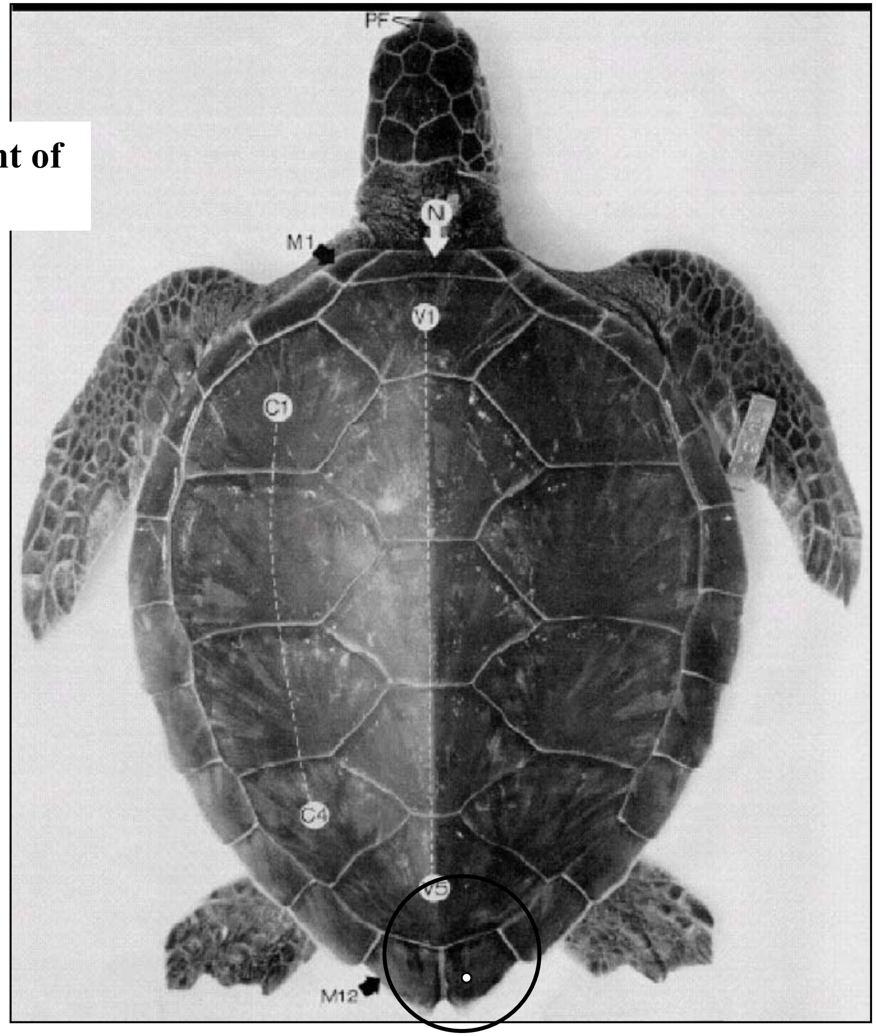
Looking Forward

As we prepare for the upcoming research season, we are planning to continue some of the aspects of this project that were highly successful. In the upcoming season, we also plan to make programming modifications to aim for longer periods of monitoring, and to alter some of the measured parameters to better align the two types of satellite transmitter data. The alternating of application of real-time transmitters and PSAT archival transmitters has great promise, especially with respect to providing essential and complementary data on turtle ecology at sea. In addition, the close scrutiny of the turtles' activity with respect to position in the water column and sea surface temperatures is likely to yield crucial information for the construction of solid predictive models upon which we can base our management decisions. It is our hope that good predictive tools will immediately contribute to further alleviating the interactions between sea turtles and the Pelagic Longline Fishery.

Fig. 1. **Instructions for Attachment of Real-Time Satellite Transmitters**

For Loggerheads > 45 cm SCL

Lightly Hooked Only

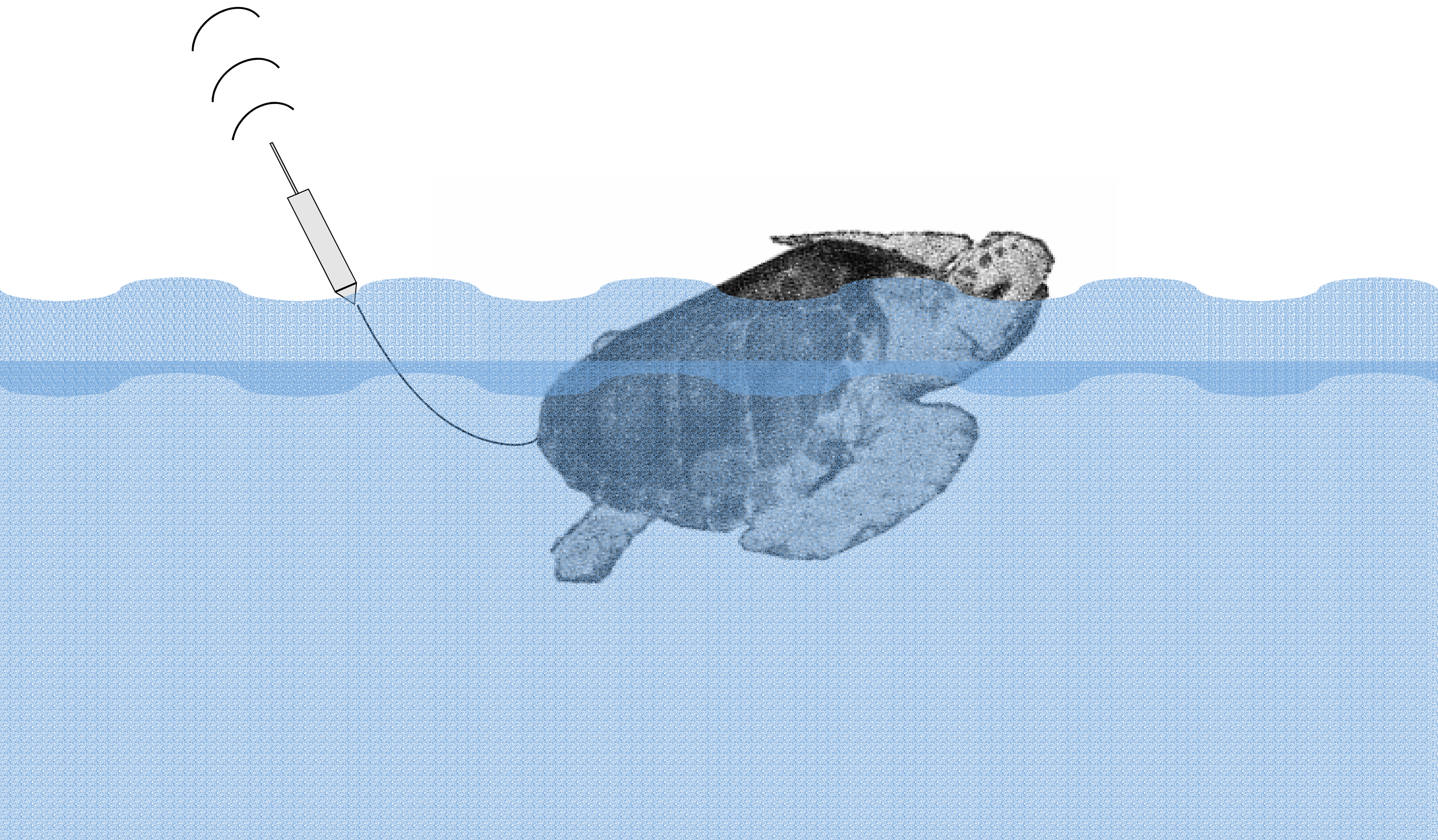


1. Choose posterior-most scute on either right, or left side of midline.
2. Clean upper and lower surface of barnacles (so they don't scrape the lanyard).
3. Drill hole 1/2 inch in from outer edge and 1/2 inch away from midline seam.
4. Make loop just large enough to move freely around the scute.
5. Crimp using the 10-12 gauge setting (the bottom crescent)
6. **Leave room to crimp twice -- Don't bear down too hard, just nice and snug.**

Stay a little away from the edge of the sleeve -- reverse crimpers on second crimp.

Check your work and let the turtle go gently into the water.

Fig. 2. Transmitters send encoded messages when the turtle rises to the surface to breathe



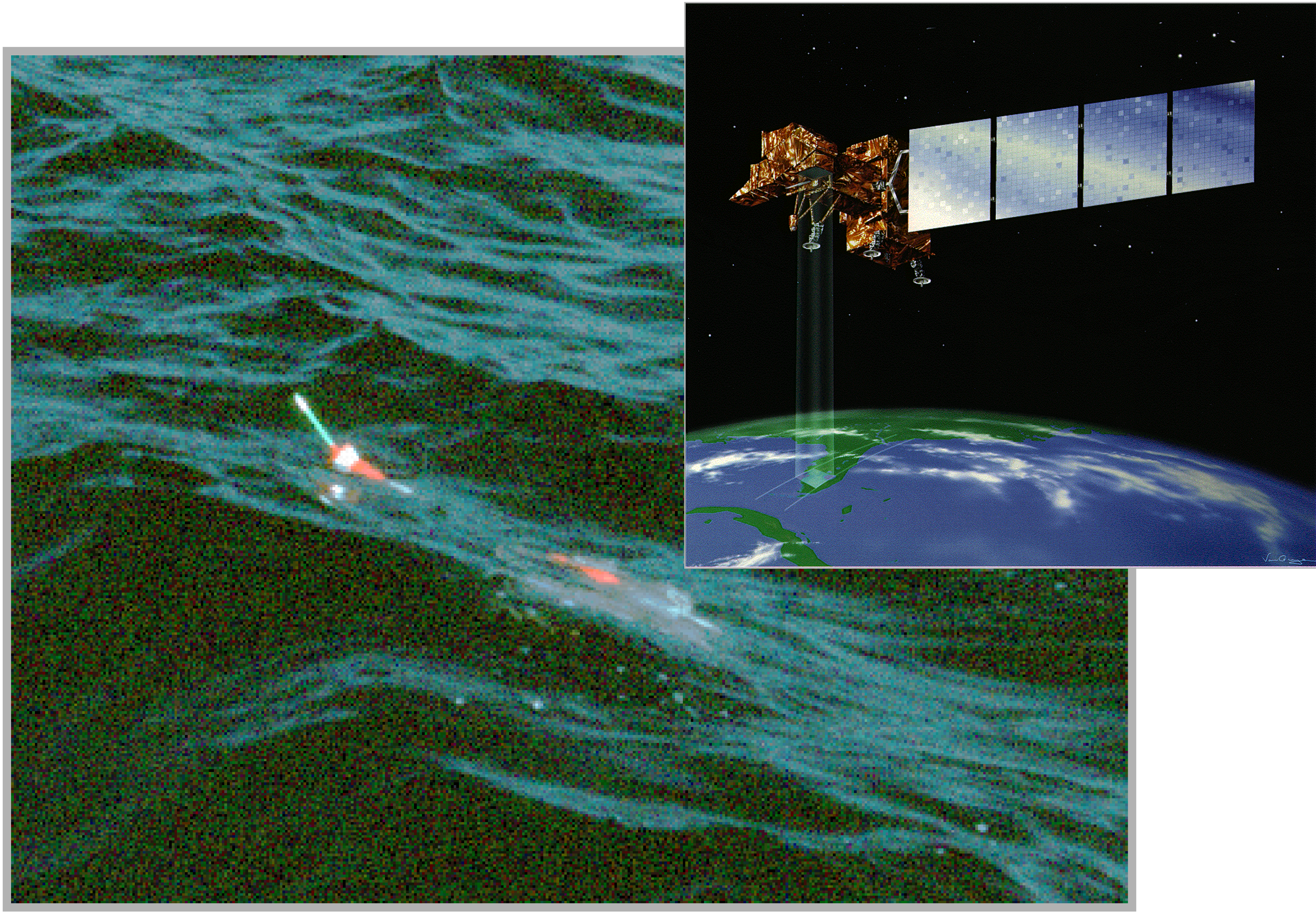
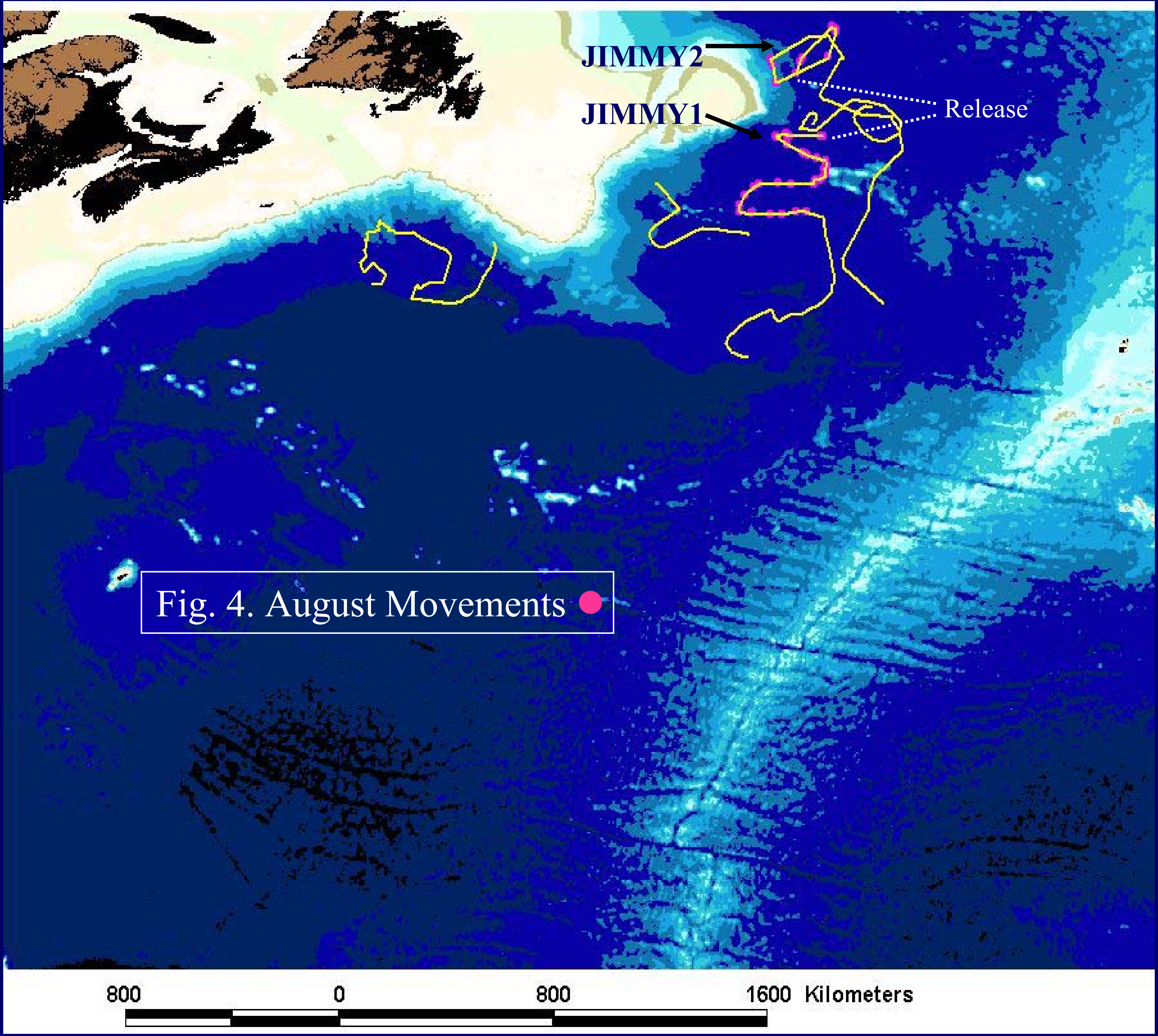


Fig. 3. A sea turtle in open waters illustrates the performance of a trailing, buoyant transmitter. In this position, the transmitter detects the surface and transmits data. The polar orbiting satellites ensure that coverage is global.



JIMMY2
JIMMY1
Release
Fig. 4. August Movements
800
0
800
1600 Kilometers

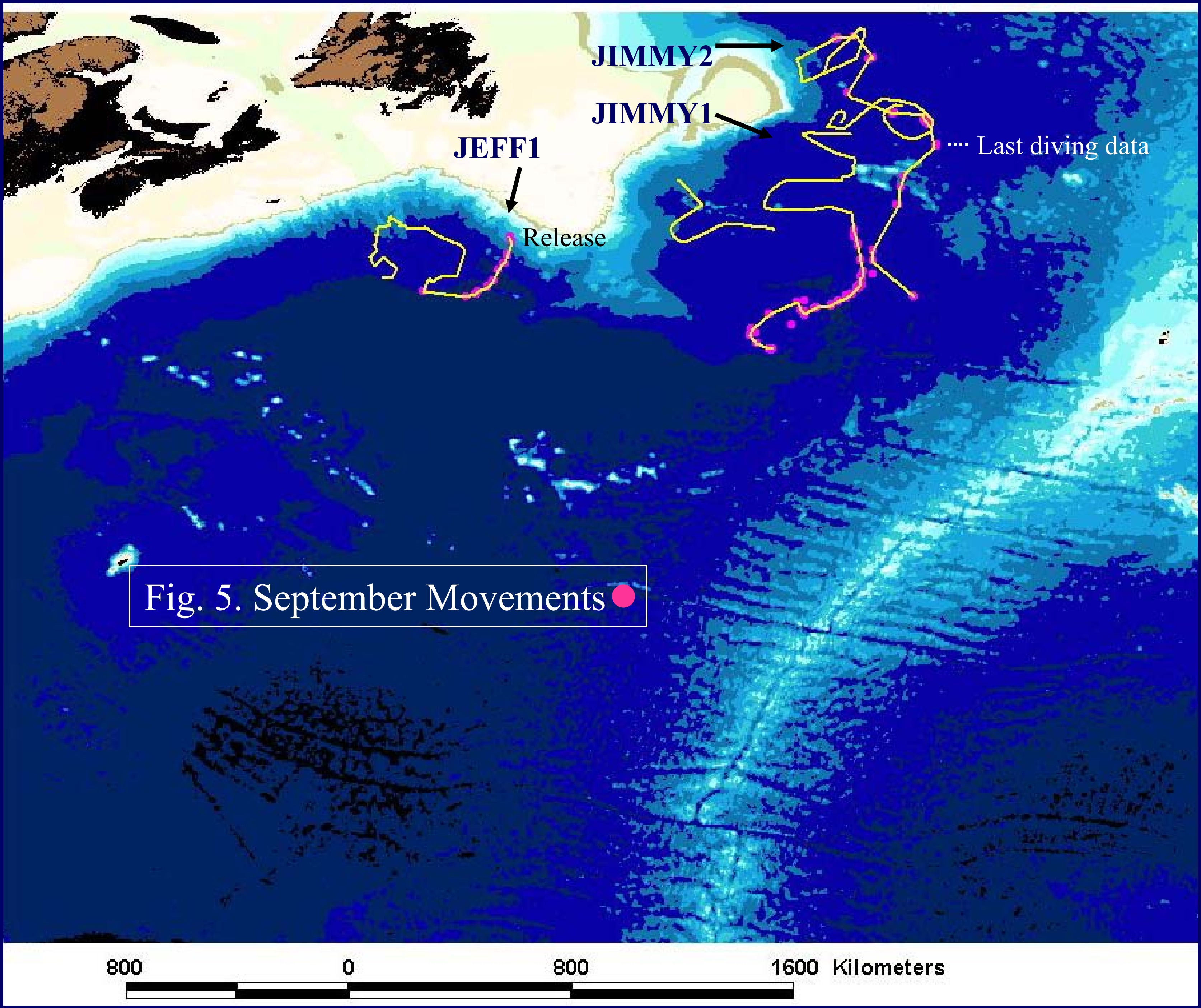


Fig. 5. September Movements

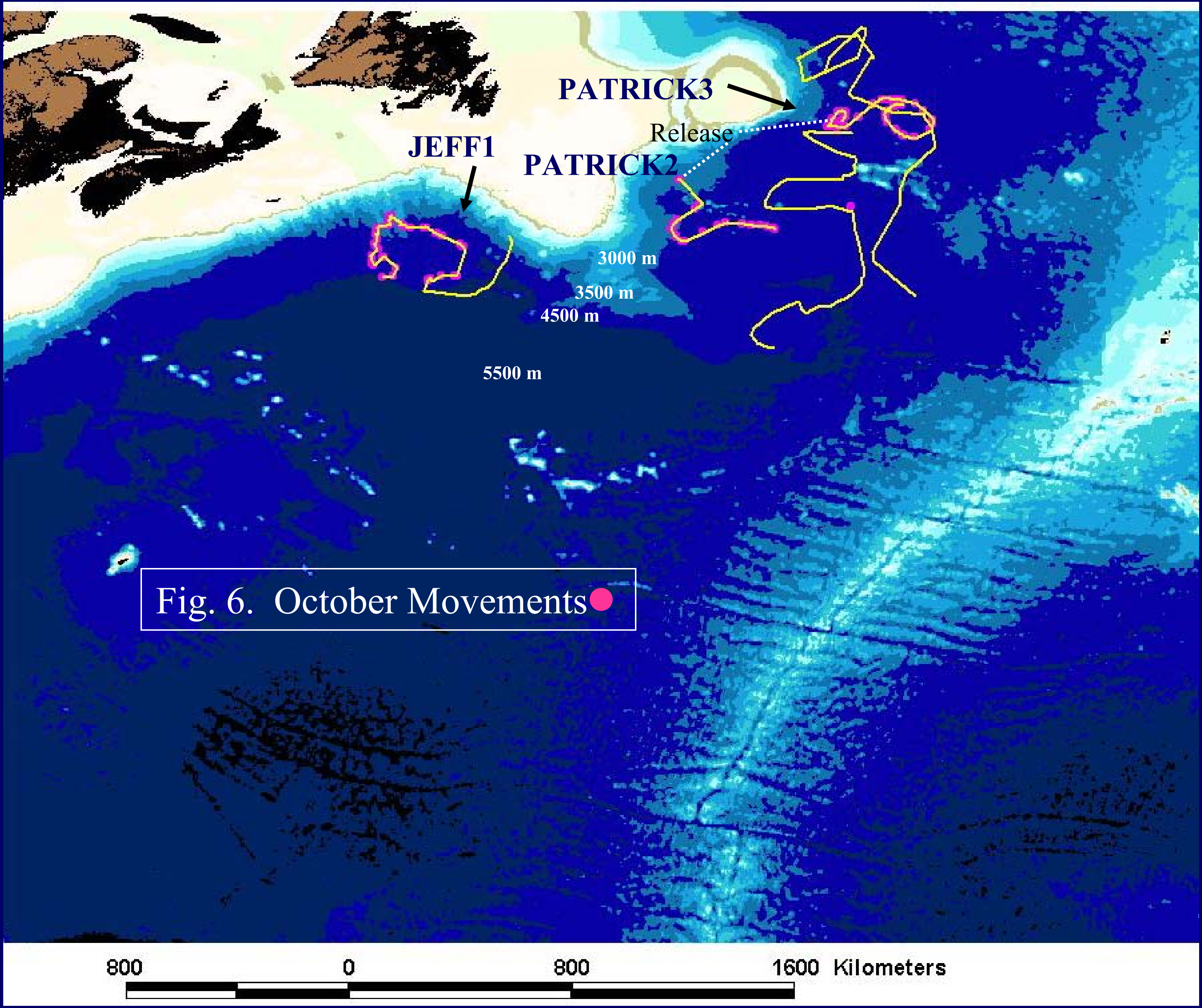


Fig. 6. October Movements

Fig. 7. Percent time spent at depth intervals throughout the water column

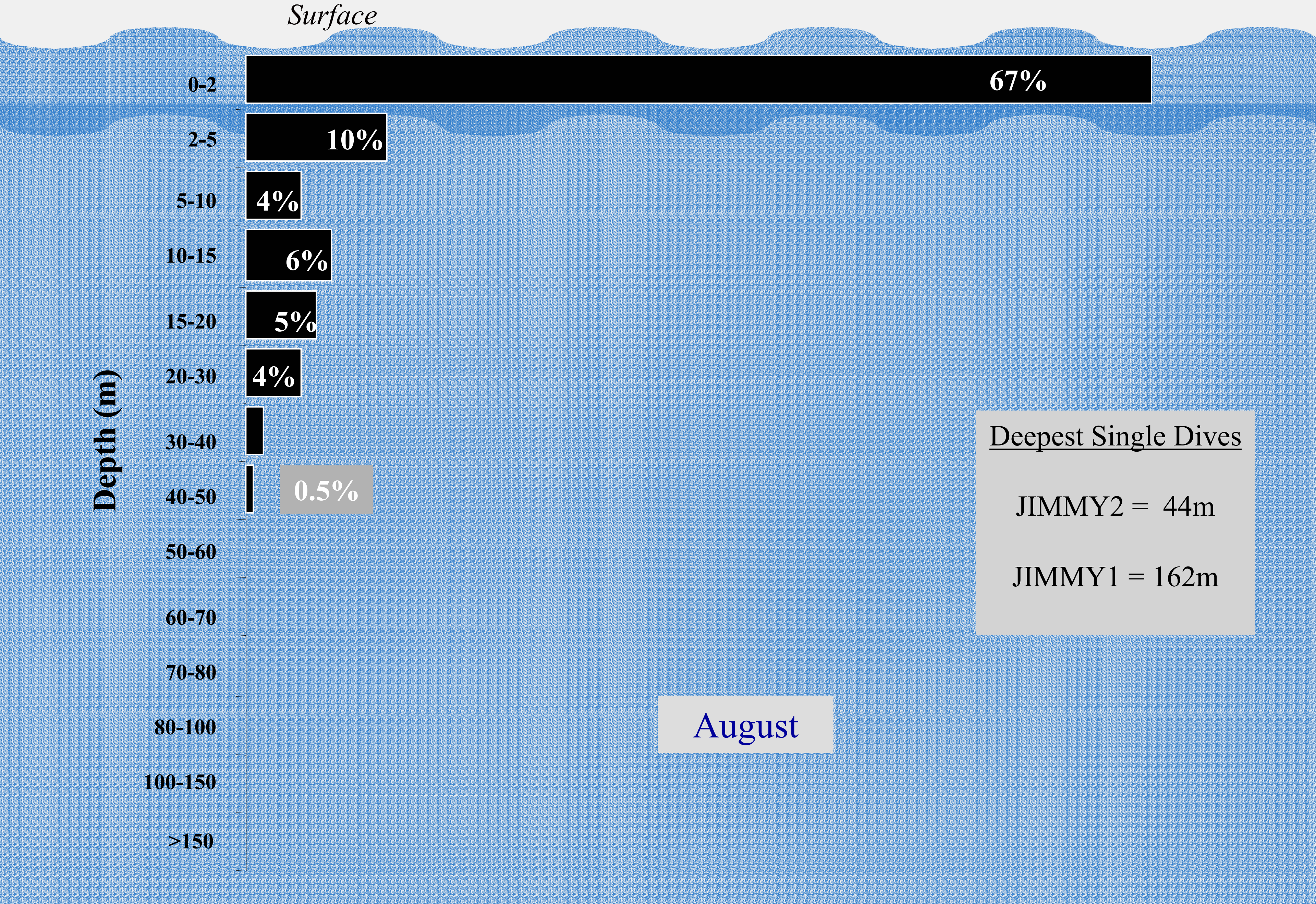


Fig. 8. Percent time spent at depth intervals throughout the water column

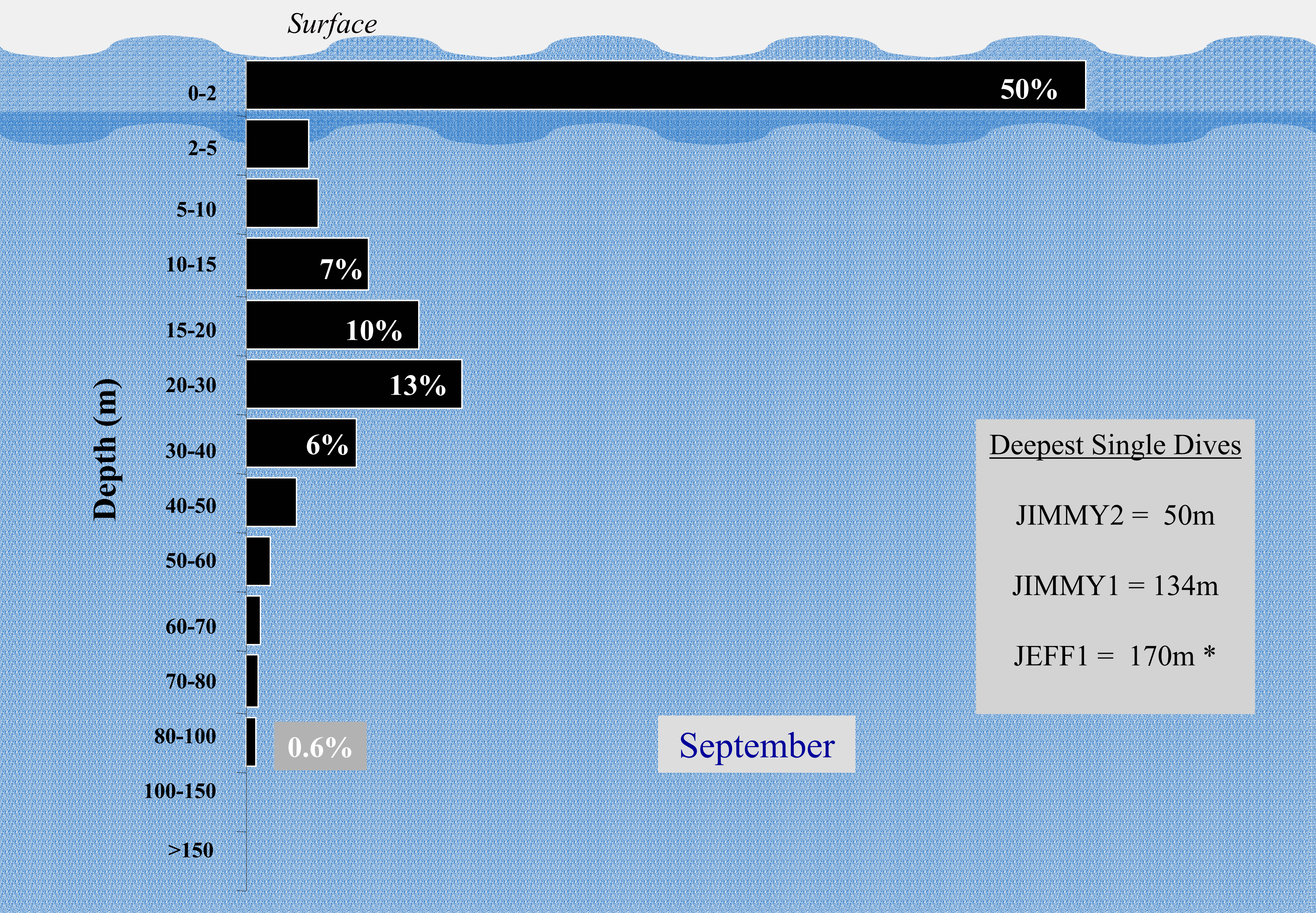
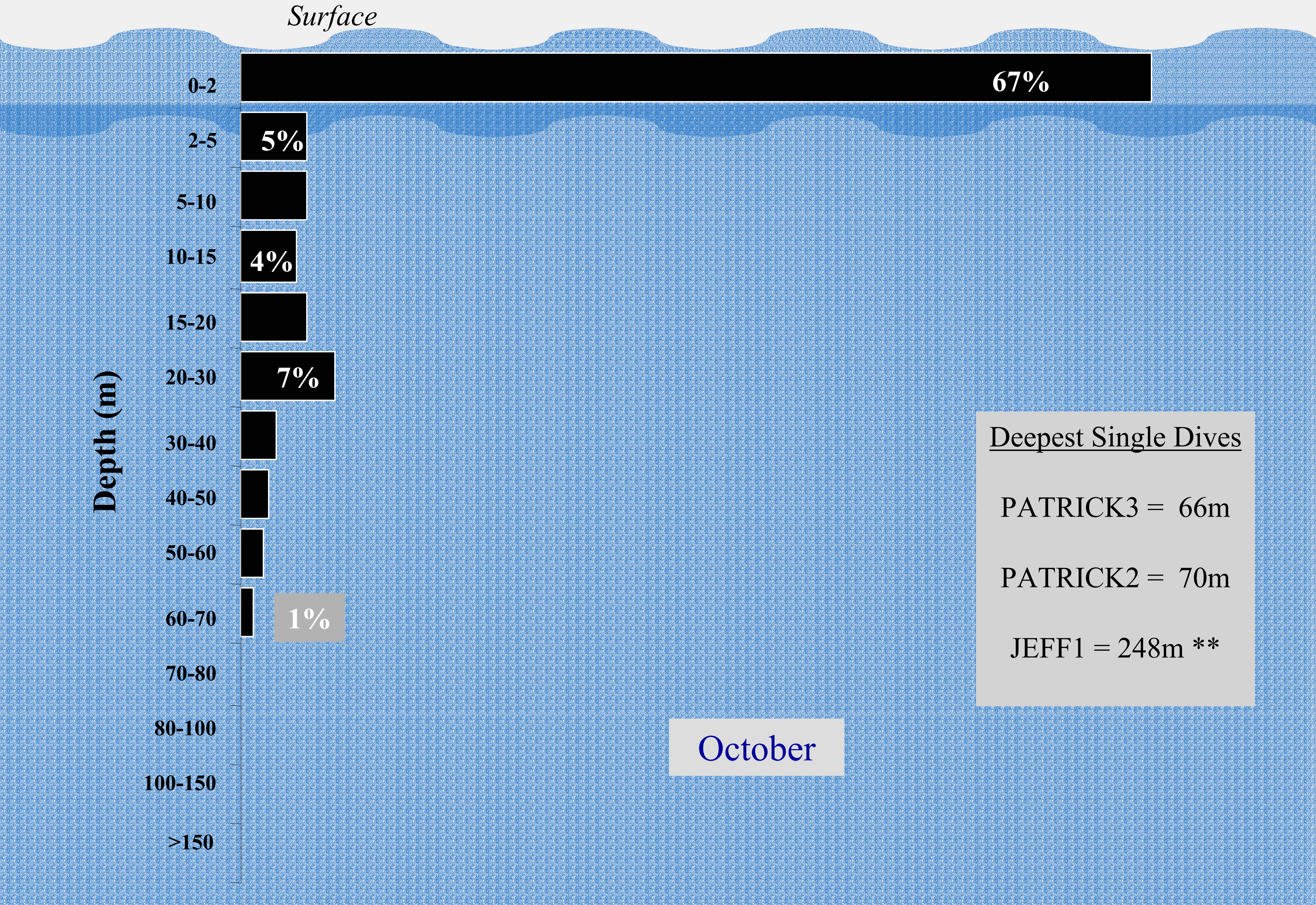


Fig. 9. Percent time spent at depth intervals throughout the water column



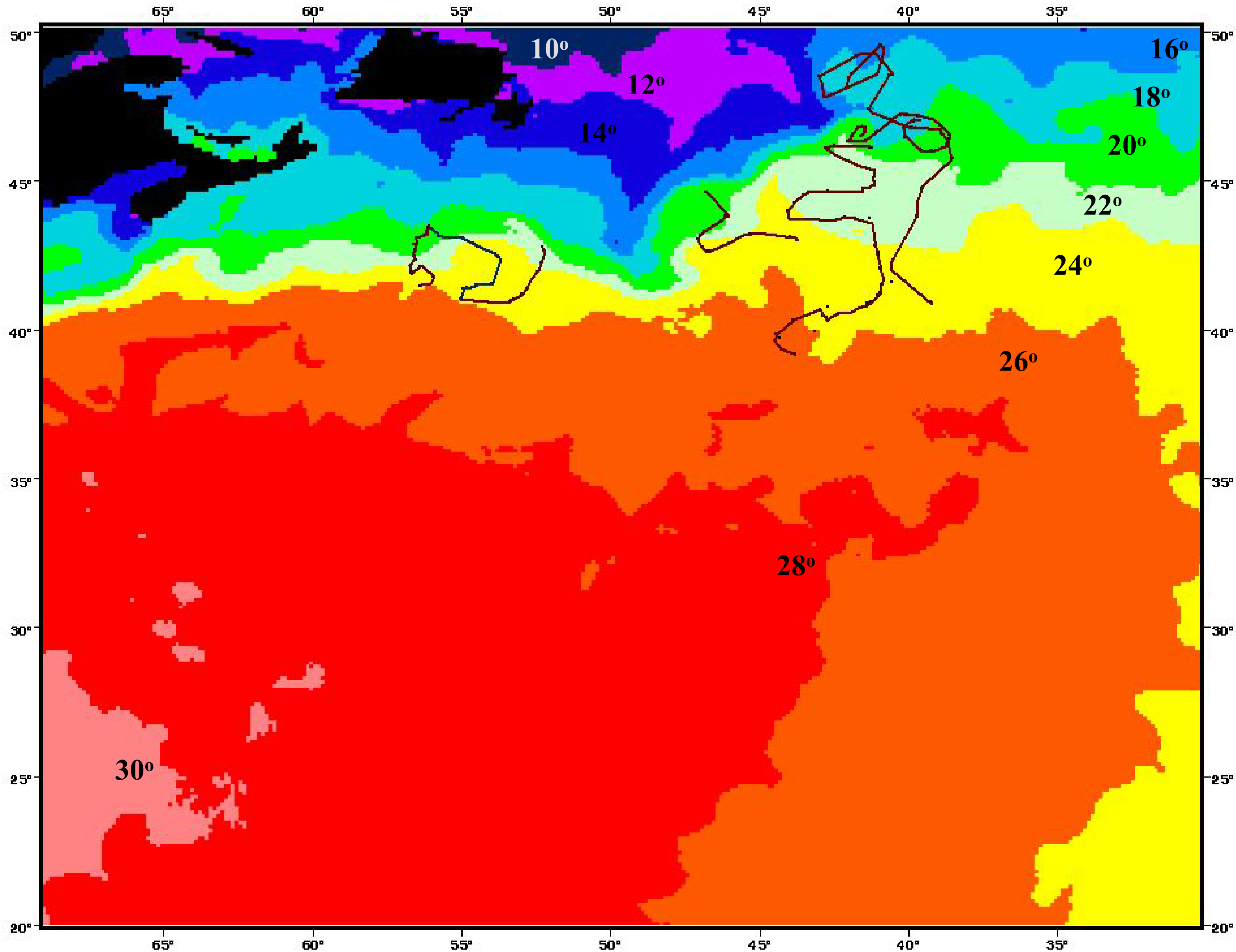


Fig. 10. Complete satellite tracks of the five loggerhead turtles with respect to mid-season water temperatures. Water temperatures are MODAS SST data for the day of 1 September 2002. (MODAS data Courtesy of NRL, Stennis Space Center)